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Devoted to the Conversion, Transmission and Distribution of Energy

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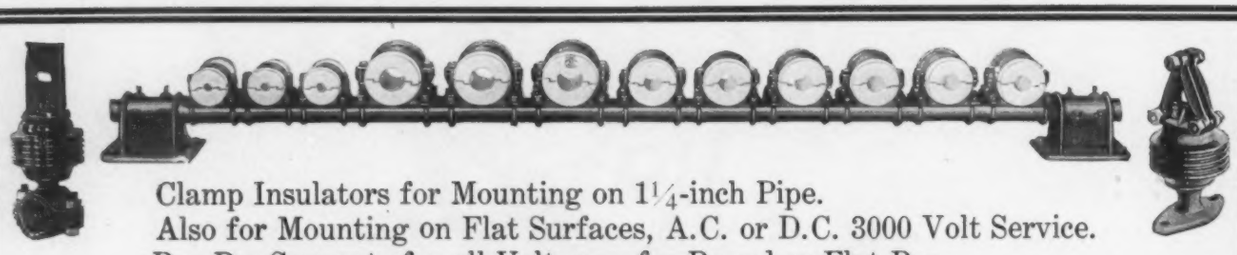

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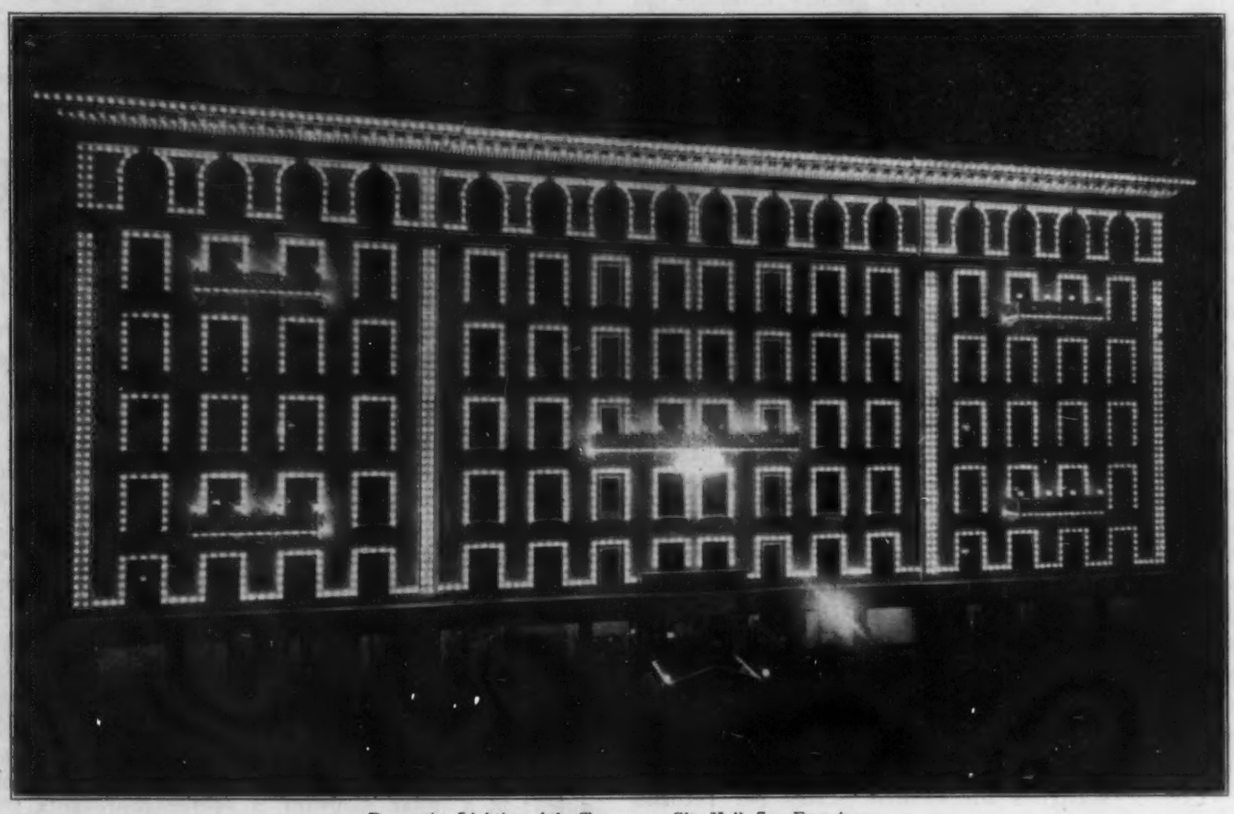
DECORATIVE LIGHTING IN SAN FRANCISCO

At 7 p. m. Friday, February 9th, Miss Cora Otis closed the switch controlling the current to the decorative lighting on the front of the new Temporary City Hall, thereby inaugurating a new era for what is to be the civic center of San Francisco.



Decorative Lighting of the Temporary City Hall, San Francisco.

The Temporary City Hall is a seven-story, reinforced concrete building, erected by the Whitcomb Estate, James Otis, trustee, and leased to the City of San Francisco for a period of three years for use as a City Hall. It is located on the southerly side of Market street, west of Eighth street, and has a frontage of 200 feet, extending back to Stevenson street, a distance of 165 feet. In it are to be housed the Mayor, Supervisors, Tax Collector, Assessor, County Clerk and the various municipal departments.

The decorative lighting system is the most complete and extensive on the Pacific Coast and was designed as an integral part of the facade, all the outlets being set in the forms before the concrete was poured.

In all 2540 five-watt, 12-volt tungsten lamps were used, outlining all the windows, balconies, pilasters and the cornice. The balcony posts and corners of the marquise are topped with 12-in., rough inside, spherical globes, each fitted with a 40-watt, 110-volt

tungsten lamp. The five-watt lamps are divided into seven sections, each section having its own transformer, located in the center of distribution, and housed in a cabinet, recessed into the front and behind the balcony, with the exception of the top, front section, the transformer for which is located on the roof.

Incorporated in the transformer housings are the secondary distribution panels, arranged as three-wire circuits, each carrying approximately 8½ amperes. Transformer primaries are fed from the 220-volt bus bars on the main switchboard, each with an independent circuit. Each balcony has, also, a separate 110-volt circuit fed from the main switchboard, permitting of any desired combination of front illumination.

Transformer secondaries are wound for 12-24 volts with an output of two kilowatts. Each secondary, three-wire circuit feeds the center of a group of thirty-five lamps.

Both primary and secondary leads are proportioned to give a practically uniform voltage to each lamp and as an economical system of decorative lighting it might be stated that the cost of operation will not exceed 45 cents per hour for the entire system.

The architects, Wright, Rushforth & Cahill, have designed a building which will greatly enhance the appearance of that section of the city and form a fitting headquarters for the progressive city officials who are to do so much for San Francisco in the next four years. Much credit is due to the Central Electric, Plumbing and Heating Company for the excellent manner in which the installation was carried out.

COPPER STATISTICS.

The United States Geological Survey have collected statistics from producers of blister copper and from Lake mines for the first eleven months of 1911. Taking these figures, and estimating the December output and incomplete returns for November, the Geological Survey report a United States production of copper for last year amounting to 1,091,554,000 pounds, against 1,080,159,509 pounds in 1910 and 1,092,951,624 pounds in 1909. Imports of copper in 1911, (Dec. estimated) were 340,480,000 pounds, and these to the above figures we have a total United States supply in 1911 of 1,432,034,000 pounds. These returns compare with the Copper Producers' report of the production of $1,431,938,338 pounds of marketable refined copper in 1911. The closeness of these two sets of statistics compiled by different authorities is remarkable.

Copper statistics for United States per returns by Producers' Association, in pounds:

	December.	November.	Increase.	Decrease.
United States production	122,896,697	111,876,601	11,020,096	
Domestic Deliveries and Exports	145,227,190	135,089,055	10,138,135	
Stock end of month	89,454,695	111,785,188		22,330,493

Total production, 1911.....1,431,938,338 lbs.
Total deliveries, 1911.....1,461,513,838 lbs.
Decrease in stocks, 1911 .. 32,575,300 lbs.

GRAPHICAL ANALYSIS OF ALTERNATING CURRENT PHENOMENA.

BY A. L. MENZIN.[1]

In the Transactions of the American Institute of Electrical Engineers for June, 1911, there appeared a discussion on the relative advantages and disadvantages of the two graphical methods of representing alternating current phenomena in common use—the so-called crank diagram, favored by some, and the polar diagram advocated by others.

Judging from this discussion, it seems to be held that although the polar diagram is more logical and broader in its scope, yet it does not serve to give as clear ideas of instantaneous relationships as well as the crank diagram.

Some time ago the writer was working on an experimental electric generator and found it necessary to work out the time-magnitude relation of induced e.m.f's. in order to predict what would happen if certain windings were modified. He found the polar diagram as commonly used unsatisfactory; and, after searching for a more suitable method, discovered that if the polar diagram—a diagram based on polar co-ordinates—is used in the restricted sense in which it is set forth in text books on analytical geometry, that is purely as a graphical method of representing values, without any reference whatever to the conventions of harmonic motion, the difficulties vanished.

It is questionable if the common use of effective values, even as a short cut to quantitative solutions, is not a serious obstacle to a clear comprehension of instantaneous relationships. Effective values, being mere averages indicated by instruments actuated on the dynamometer principle, are therefore not actually referable with respect to time. To give them a false time relationship is to give them a significance which obscures their real meaning.

Another difficulty is the association of the term rotation in connection with polar diagrams. Rotation is no more inherent in the polar co-ordinate system than is the notion of translation in the rectangular system. In a very special case, that of the bi-polar machine, the period becomes co-incident with one revolution of the armature and, in this case, one may consider the rotating vector as representative of a rotating armature conductor. But when this notion is extended to multipolar machines, confusion begins.

To use the polar diagram in its mathematical sense, it is necessary to go back to first principles. The key to any system of plane co-ordinates is that a simple graphical mark represents two separate and distinct magnitudes. Thus, in a diagram based on rectangular co-ordinates, a point represents two magnitudes by its distances from two fixed lines at right angles; in a polar diagram, a vector represents two magnitudes by its length and by its angular displacement with respect to a fixed line. If there is some continuous relationship between the magnitudes, the points in the first mentioned diagram, and the vectors in the other, become adjacent and the result is a line, or curve, which is called the "graph" of the phenomenon represented, or the "locus" of the equation which expresses the relationship.

[1]Mechanical Engineer, San Francisco.

Thus in Fig. 1, O is a fixed point called the "origin" from which all vectors begin, O A is a fixed line called the "initial line from which angular distance is measured, and M N is the graph showing the relations between the magnitude plotted in lengths

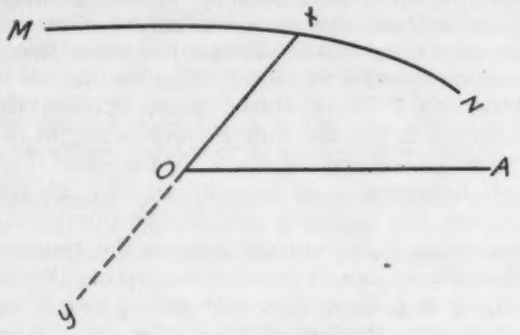


Fig. 1. A Polar Graph.

of vectors and the magnitude plotted in angular displacement of those vectors. Any vector as O X represents one magnitude by the length O X, and the corresponding magnitude by the angle A O X. The length of the vector is positive when measured along the closing side of the angle considered, and negative when measured in an opposite direction. The angle is positive when measured in a counter-clockwise direction and negative when in a reverse direction. Thus in Fig. 1, the length of the vector corresponding to the angle A O X is O X and is positive; the length of the vector corresponding to the angle A O Y is also O X but is negative.

Due to the usual mechanical construction of electrical machines and to the laws governing magnetic induction, the instantaneous relationship between time and e.m.f., current, flux, etc., is expressed approximately by an equation of the form $i = I \sin \frac{2\pi}{T} t$

where i is the instantaneous value of the oscillatory quantity, I the maximum value, T the period of the oscillation, and t the time corresponding to the value i measured from the beginning of the oscillation.

If, in a polar diagram, time is plotted as angular displacement to the scale of one degree or 1/360th of the period, then the period is $T = 360°$, or 2π, and, by substitution, the above equation becomes $i = I \sin t$, where t is now expressed in degrees. By referring to text books on analytical geometry it will be found that the polar locus of an equation similar to the above is a circle passing through the origin whose center lies on a line 90° distant from the initial line. It is evident that the angular position of the initial line will not affect the shape of the curve, the only effect of placing the initial line elsewhere than at 90° to the diameter is to change the arbitrary zero of time. It is also evident that the maximum vector which can be drawn from the origin, which must always be on the circle, is the diameter. From the above follows the fundamental fact that the polar graph of every oscillatory magnitude expressed by an equation of the form $i = I \sin \frac{2\pi}{T} t$ is a circle passing through the origin when time is plotted to the scale of $360° = T$. The diameter of this circle is equal to the maximum value of i.

One reason for the adoption of the polar diagram in representing alternating current phenomena is now seen; for, next to the straight line, the circle is the simplest curve to draw. But there are other reasons.

The superimposed or additive effect of two or more oscillatory magnitudes whose graphs are circles through the origin is also represented by an equation of the form $i = I \sin \frac{2\pi}{T} t$, and the graph of this effect is also a circle whose vectorial diameter—the diameter which originates at the origin—is determined in length and position by taking the vector sum of the vectorial diameters of the component circles, which may be done by the parallelogram method.

Before considering a problem involving the above it is necessary to define a few terms in common use. The term "phase," like many other words, has various meanings but its significance in this discussion is taken to be the time corresponding to a given instantaneous value. Thus the phase of the maximum value of a current is the time when that current is existent. From this it is evident that such expressions as "phase of a current" is indefinite unless some particular value of the current is specified or understood. Since every vector represents a length and an angle, it is proper, when the angle represents time, to speak of the phase of a vector, meaning the time corresponding to the magnitude which the length represents. Phase difference means difference in time between two instantaneous values. Thus the phase difference between the zero and maximum values of an alternating current is one-quarter of a period, and the phase difference between the maximum values of two currents of a three-phase system is one-third of a period.

One instantaneous value "lags" behind another when it becomes existent at a later time, and "leads" another when it becomes existent at an earlier time. Thus, the maximum value of the current from an induction motor lags behind the maximum value of the impressed e.m.f. because the current reaches this value later and vice versa, the maximum value of the e.m.f. leads the maximum value of the current because the e.m.f. reaches this value earlier.

To be consistent with the above expressions such as "the current lags 15 degrees behind the e.m.f.," must be stated differently. The terms lead and lag, as defined above, have to do with time, and therefore have no inherent relation to angular measure. From this point of view it is no more consistent to say that "a current lags 15 degrees," because time is represented in angular measure on a diagram than it is to say "the temperature rise is 15 inches," because temperature happens to be represented on a diagram in linear distance. A correct way of stating the above is to say that the current (meaning the maximum value) lags 15/360ths of a period behind the e.m.f. This is true no matter what system of co-ordinates is employed and has the very great advantage of keeping in mind the real significance of the terms phase,

phase-difference, lead and lag, without detracting in any way from the readiness with which these may be represented in polar or rectangular co-ordinates.

To show clearly the application of the principles stated above, a simple alternating current circuit will be considered. Fig. 2 shows this circuit diagrammatically and the graphical representation of the electromotive forces involved. This latter is brought about as follows: Draw the vector O — I to represent the phase of the maximum value of the current. Then the maximum counter e.m.f. of resistance will lie along the vector O — I R, displaced by a half-period since the e.m.f. of the resistance always opposes the current and is proportional to it. Let O — I R equal the maximum value of this e.m.f. to some convenient scale, and circumscribe the circle about this vector as a diameter. This circle is the graph which shows the value of the counter e.m.f. of resistance at every instant. The maximum value of the e.m.f. produced by self induction lags one-quarter of a period behind the maximum value of the current. Its phase is therefore represented by the vector O — I X. Let the

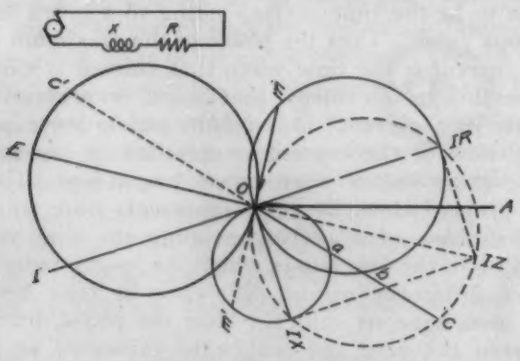


Fig. 2. Graphs of Electro-motive Forces in a Single Phase Circuit.

length O — I X equal the maximum value of this e.m.f. and circumscribe the corresponding circle. This latter represents all instantaneous values of the e.m.f. of self induction in phase and magnitude. To find the maximum value of an e.m.f. which represents the sum of the e.m.f's. of resistance and induction draw the parallelogram with sides O — I R and O — I X. The diagonal O — I Z is this maximum value and the circle circumscribed about O — I Z is the graph of the equivalent e.m.f. Since, by Kerchoff's law, the impressed e.m.f. must be equal and opposed to the resultant of all other e.m.f's. at every instant, the phase of the maximum value of the impressed e.m.f. is represented by the vector O — E displaced one-half a period from the resultant maximum e.m.f. O — I Z. Also the length O — E must equal O — I Z. The circle circumscribed about O — E is the graph of the impressed e.m.f. at every instant.

From the circles O E, O I R and O I X, the corresponding values of all e.m.f's. at any instant may be determined by measuring the intercepts on a vector corresponding to the instant in mind. Thus, at the time corresponding to the vector O — c the counter e.m.f. of resistance is represented by the length O — b, the e.m.f. of self induction by the length O — a, the resultant counter e.m.f. by the length O — c, and the impressed e.m.f. by the length O — c'. By Kerchoff's law, O — c' must equal (O — a) + (O — b).

At the time corresponding to the vector O — c, the e.m.f. of both resistance and induction are opposed to the impressed e.m.f. At the time corresponding to the vector O — I R the e.m.f. of self induction is zero and the e.m.f. of resistance alone opposes the impressed e.m.f. At the time corresponding to the vector O M the impressed e.m.f. is zero but the e.m.f. of self induction is of opposite sign to the e.m.f. of resistance, and therefore acts like an impressed e.m.f. in maintaining the current against the resistance R. And so on.

It is thus seen that the polar diagram as here used offers an exceedingly simple means of representing the characteristics and instantaneous values of the oscillatory quantities met with in electrical theory. For the purpose of determining instantaneous values the polar diagram is much simpler than the crank diagram; for, in the polar diagram it is only necessary to draw a line, while in the crank diagram it is necessary to draw a line and project the vectors upon it.

To use the polar diagram as above it is necessary that maximum values be known. These are not directly obtainable since instruments indicate "effective" values—the square root of the mean square of the instantaneous values. Fortunately, when the instantaneous value varies according to the sine law, the maximum value is equal to the effective value $\times \sqrt{2}$. Hence the one may be computed from the other arithmetically or may be scaled direct from the diagram by changing the scale factor. The maximum values may therefore be used at all times in graphical analysis without disadvantage.

It is seen from the problem considered above that the circle plays no part in the quantitative determination of the resultant maximum value of two or more component values. Only the vectorial diameters are used. Since one circle and only one can be circumscribed about a given diameter, the circles need not be drawn unless it is desired to analyze the problem qualitatively as well as quantitatively.

The polar co-ordinate system as here used differs from the method commonly taught in that all reference to the theory of harmonic motion has been avoided. One could be totally ignorant of the meaning of such words as wave, amplitude, projection, etc., and yet be able to use the polar diagram understandingly. As an instance, one may cite the readiness with which power plant operators learn to read the circular records made by the clock-driven recording instruments. These records are polar diagrams in the same sense as those used in this article and, although the ruling is sometimes modified on account of the mechanism which operates the pen, the theory is the same. An instrument might be devised which would draw the polar graph of a current as a parallel to the graph in rectangular co-ordinates drawn by the instrument known as the oscillograph.

POLARITY IN POLYPHASE CURRENT CIRCUITS.[1]

BY PROF. R. W. SORENSON.

The subject, which soon must be considered more generally and standardized, is the one of d.c. polarity, and by presenting a few practical problems we can see the value of its application.

Prof. Ryan has called our attention early in his paper to the well known and hence so often forgotten fact that it is the external angle between vector circuits, representing polyphase currents or electromotive forces, that measures their difference in phase, thus permitting the addition of these quantities without the use of an extra negative sign as is so often the practice.

Before taking up the specific problems which I wish to use to illustrate the value of a careful analysis of polyphase polarity, let us get before us the relation of electric quantities in picture and in vector diagram, and also a general idea of what polarity is in any alternating current circuit.

In Figs "1a" and "1b" there is represented by vectors and by rectangular co-ordinates, a balanced three-phase system of currents in Y connected circuits. Now let the maximum value of these currents be 1.0, then at the instant when the current in phase A has reached this value or what may be called the positive side of the base line, that is, has a value of + 1.0, it will be seen from the figure that phases

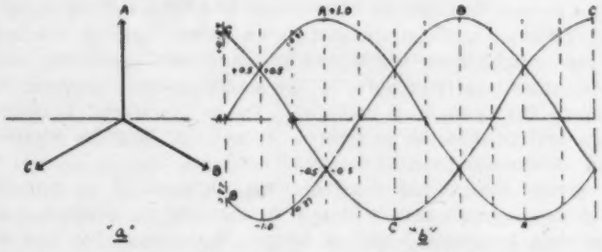


Fig. 1. A Balanced Three-Phase System.

B and C are each equal to —0.5. If, in addition to this system of designating these quantities, we assign to a rising current a + sign to show its direction or instead of using this sign a "O" is used at the instant chosen (when phase A is at maximum value) in order to avoid confusion, phase A can be designated by the double sign "+O", phase B by "— O" and phase C simply by the sign "—". Here no direction sign is used in showing the negative action of the circuit, the sign as shown for C really stands for a double negative. That is, it is very evident that to be completely represented as to direction and also with relation to its circuit, each phase must carry with it a double sign, one to represent the position of the circuit and one to represent the direction of the current of electromotive force at any instant. Also it is evident that there is a constant relation between the currents in the different phases and that any equation which may express the value of the current in one phase will serve to express the value of the current in either of the other phases by the simple addition of a constant which expresses the phase relation between the quantities represented.

Since the condition here outlined is that which may occur at any instant, we may conclude that it represents every instant, and thereby gives us a most definite basis for the establishment of such a thing as polyphase polarity.

In considering polarity in any a.c. system, whether single phase or polyphase, as compared to polarity in a d.c. circuit, there are these differences: the relation between current flow and the circuit in a d.c. system is constant, whereas in an a.c. system the current or electromotive forces are continually changing and repeating every cycle; and there can be no difference of phase between d.c. currents in circuits which are joined together, and moreover there can be a difference in phase between currents or voltages in a.c. circuits that are joined together.

As to a.c. polarity in general, let us consider for a few moments the single phase transformer. All of us know that when we wish to multiple two or more of these, we must first determine the polarity and connect together leads which have like signs, in accordance with the method used to des-

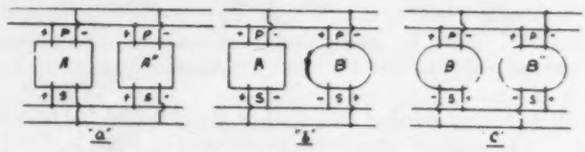


Fig. 2. Single Phase Transformers in Multiple.

ignate leads which go together and thence to the lines. This can of course be most conveniently done by marking one primary lead of each transformer "+" and the other "—" after which the same thing is done in regard to the secondary leads as in Fig. 2, due consideration being given to the relation between the P winding and the S winding in each case. With only the single phase relations to consider, this is of course, perfectly proper, and is fully warranted by the simplicity of such a designation, but when these same single phase transformers are to make up a part of some polyphase set there must also be added the other sign, for reasons which will be developed later, and hence in order to lead up to this, I will show the vector circuits for two open core single phase transformers as illustrated in Fig. 3. To do this we must first establish a standard, which can be done in one of two ways. The transformer can be considered as a motor generator set, with the primary as the motor and the secondary as the generator, in which case to be analogous with the system used in direct currents an instant would be selected when the current was going into a particular lead of the primary winding and the direction the current then had in this lead called "+", at this same instant the lead on the secondary side in which the current is flowing out as in a generator would be given the sign "+", which lead this would be, being determined by the direction in which the secondary is wound as compared to direction of winding of the primary. Or another plan may be adopted in which both primary or secondary leads carrying current into the transformer at some particular instant are designated as the positive leads.

This latter method is I believe the one most generally used because of the fact that it so readily lends itself to the determination of transformer polarity by the direct current method, although personally I am in favor of the first scheme suggested, viz: that of calling the secondary winding a gen-

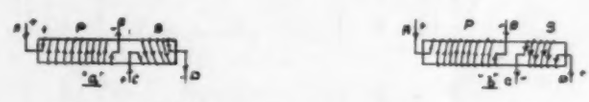


Fig. 3. Vector Circuits for Two Open-Core Single Phase Transformers.

erator and the primary winding a motor. But for the present we will adhere to the other standard and determine our polarity by the direct current which is as follows:

Given a transformer as in Fig. 4, to determine its polarity.

Connect to the primary coil leads A and B a direct current supply of low voltage so that only a small current will flow. If lead A is connected to the positive side of the d.c. supply and B to the negative, place a d.c. voltmeter on the leads C and D with the positive terminal connected to C and the negative terminal connected to D. Now suddenly break the circuit connected to C-D by opening switch S quickly and the voltmeter V will show a deflection or "Kick." If this kick is

[1]This paper is a discussion of Professor Ryan's paper on Polarity in Polyphase Circuits which was presented at a meeting of the Los Angeles Section of the A. I. E. E., Nov. 21, 1911, and appeared in the columns of the Journal on Nov. 11, 1911.

over the scale the polarity of lead C is marked the same as that of A, as in Fig. 4, thus indicating that the coils P and S are wound in opposite directions as in Fig. 3a. Had the kick been in opposite direction it would have indicated a transformer with the P and S coils wound in the same direction as in Fig. 3b.

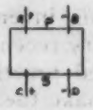


Fig. 4.

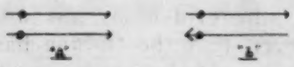


Fig. 5.

Having decided that this shall be the standard for polarity and that it shall be designated by signs as in Figs. 2, 3 and 4 which one has a perfect right to do, as there is no established standard, the manufacturer must actually or theoretically place in his shop a standard transformer so marked and with which all transformers built must be compared.

Showing the vector circuits for the transformers "a" and "b" in Fig. 3 we then have what is given in Fig. 5 when the "O" is added to show that in every case the left hand terminal is taken as the positive terminal of the circuit in which the current flows. Having now in mind a general analysis of a.c. polarity it can be applied in polyphase conditions, some of which can only be worked out when account is taken of both the electric and circuit polarity.

In the factory, rotating machines, in which there is but one winding per phase, such as alternators, or synchronous motors, are checked for polarity by means of what in shop language is called a "Phase Wagon." This is a little instrument consisting of a magnetized bar supported on a post at its center around which is an iron ring and upon this there is a three-phase winding, the terminals of which are brought out to binding posts numbered 1, 2 and 3. If, when the leads of the machine under test are connected according to instructions given, to the posts 1, 2 and 3, the bar turns on its pivot in the proper direction, the machine is said to have correct polarity and phase rotation.

For frequency changers and polyphase transformers, apparatus in which there are two windings per phase, the question of getting the proper phase relations cannot be so simply accomplished, because in these cases account must be taken of both polarity and phase displacement. The "Phase Wagon" obviously will not suffice for such cases as it can show phase rotation only. Neither can the phase displacement be determined by any convenient polarity test such as is applied to single phase transformers. Hence there must be

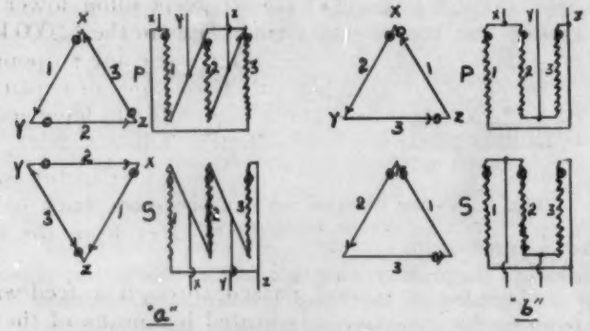


Fig. 6. Diagrammatic Delta-delta Connection of Two Three-Phase Transformers.

maintained a three-phase standard to be used for checking the polarity of three-phase machines that are built in the shops. The proper execution of this test on an efficient basis as well as the proper design of polyphase apparatus of this kind requires that a method for checking the rotation between the phases, graphically or by means of vectors, be devised.

For illustration refer to Fig. 6 which shows diagrammatically two three-phase transformers connected delta-delta, but with such relation between coils as to prevent any scheme of connections being made which will permit multiple operation without a re-arrangement of coil connections. Fig. 6a represents both by diagrams and vectors the conditions in a core

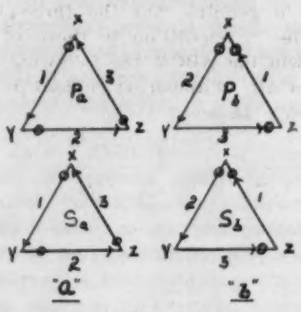


Fig. 7.

Fig. 8.

type transformer, while Fig. 6b shows the same thing for a shell type, the P coils of which are connected to the same three-phase line XA to XB; YA to YB; and ZA to ZB. These diagrams on inspection show very clearly that the secondaries cannot similarly go together, as has been already stated.

To apply to these transformers a vector diagram solution of an arrangement which will give multiple operation, consider the shell type unit "b" as standard and proceed to change the core type unit "a". To be connected together it is evident that the vectors of "a" and "b" must be parallel and of like direction as in Fig. 7.

From the vector diagram thus obtained it is evident that the negative end of circuit S—1 should be connected to the ring, or positive end of circuit 2, the negative end of circuit 2 to the ring, or positive end of S—3 and so on. As in Fig. 8, when this is performed, the transformers, if of proper characteristics otherwise, will multiple with the P leads and S leads XA to XB; YA to YB; and ZA to ZB as in Fig. 9.

It is well to note the primary coils of these transformers are wound in opposite directions as in Fig. 3a.

Transformation of power from one voltage to another by means of auto-transformers or compensators offers another very fertile field for the use of vector circuits, especially in the consideration of polyphase changes. For example let us assume that we wish to find the most economical way of changing 100 k.v.a. at an e.m.f. of 1000 volts, two-phase to three-phase power at the same voltage.

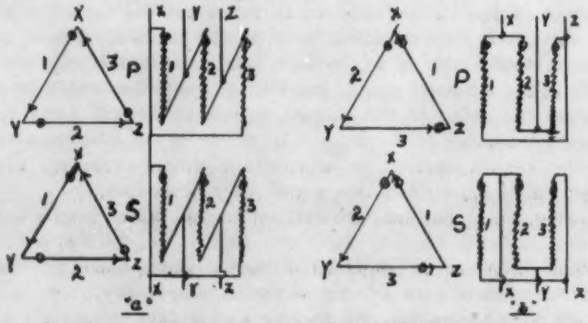


Fig. 9. Illustrating Connections to be Made.

This change can of course be made by means of two transformers each having a capacity of 50 k.v.a. which are properly wound for three-phase two-phase transformation of power when "Scott" connected, but there is a cheaper way than this both in point of first cost and in economy of operation and that is by the use of a "T" or "Scott" connected auto-trans-

former, or compensator as illustrated in Fig. 10a. The vector current diagram is shown in Fig. 10b.

Conditions of operation:

Two-phase.		Three-phase.
1000	volts	1000
100	K.V.A.	100
50	amperes per line	57.7

Inasmuch as the change of voltage is made by transformer action we can say in general that the three-phase voltages and currents will be in opposition to those of the two-phase circuits. In the winding ABCM the following conditions will exist. Current in AB, 50 amperes; current in BM, (50-57.7) amperes equals —7.7 amperes.

In circuit DM there flows a three-phase current in the direction indicated by vector circuit DC, and a two-phase current shown by vector DM, while in circuit ME there exists a similar condition as shown by vector circuits CE and ME.

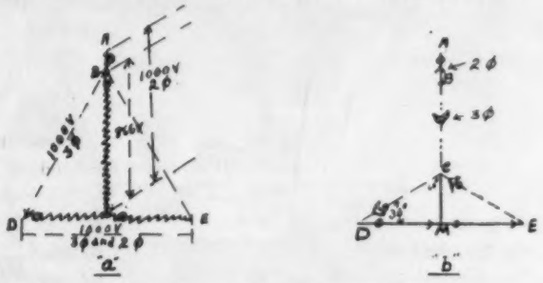


Fig. 10. Scott Connection of Transformers.

Now from the figure 10b, it is evident that, a part of the current CD is in phase opposition to current DM and also since there is no current directly in phase with the vector CD the current CM must be carried by the circuit DM figure 10a. Or for this special case there will flow in circuit DM the current represented by vector CM, which is one-half current CD, as will be seen by an inspection of the right triangle CDM. For the general case in which the three-phase and two-phase voltages are not equal, the current in each half of the winding of the main transformer will be found by the equation

$$I = \sqrt{(I_2 - .866\, I_3)^2 + \left(\frac{I_3}{2}\right)^2}$$

When I is the current flowing in the main transformer,

I_2 is the two-phase line current

I_3 is the three-phase current.

For the problem which we are working we have

$$I = \sqrt{(50 - .866 \times 57.7) + \left(\frac{58}{2}\right)^2} = 29 \text{ amperes.}$$

Summing up and tabulating we have:

Circuit.	Current.	Volts.	K.V.A.
AB	50 amps.	134	6.7
BM	7.7 "	866	6.7
DM	29 "	500	14.5
	29 "	500	14.5
Total			44.4

A transformer has, however, two windings, each of which will carry the k.v.a. rating while the auto-transformer or compensator has but one winding in which there is 44.4 k.v.a. This rated on a transformer basis would be $\frac{44.4}{2}$, or a 22 k.v.a. auto-transformer. That is for this particular case the 100 k.v.a. can be changed from 100 volts, three-phase by the purchase of a 22 k.v.a. auto-transformer rather than with two 50 k.v.a. transformers which must have in the three-phase winding 15 per cent excess of copper over that of a standard transformer and in operation this transformation will be accomplished with only such loss as will occur in a transformer of 22 k.v.a. capacity instead of with the loss due to the placing of two 50 k.v.a. transformers in the system.

THE FIRST PRINCIPLES OF THE STEAM TURBINE.[1]

BY ROBERT SIBLEY.

Historically the steam turbine is not a new idea. Hero, years before the dawn of the Christian era, invented as a play-thing, the steam turbine. Steam emerging from bent tubes caused this invention of Hero's to revolve. It was not until very recent times, however, that the turbine has assumed practical importance. De Laval was the first to make the turbine of practical value in order to utilize the energy inherent in steam to its fullest extent.

We have seen previously that enormous ranges of expansion of the steam are necessary in order to operate at maximum efficiency. Velocities almost beyond human conception are produced by allowing steam to expand adiabatically from high pressures and temperatures to extremely low pressures and temperatures. We shall soon see that in order to transform all of this energy of velocity by means of rotating buckets, the buckets themselves should move with a velocity equal, theoretically at least, to one-half the velocity of this issuing steam. The utilization of such enormous velocities early met with unsurmountable mechanical difficulties.

The first application of the steam turbine was in the separating of cream on the farm. The enormous velocities produced easily caused the cream to separate by means of centrifugal force. De Laval, however, found it necessary to make a movable shaft support for his rotating parts due to the great velocities experienced and the uneven forces encountered. This was done in order to allow the pivot of rotation to at all times coincide with the center of gravity of the rotating parts.

The immense practical application of the steam turbine so far as power development is concerned is in a great measure due to the inventions of Parsons and Curtis whereby the steam is utilized through several stages of expansion. We shall soon see that the velocity produced bears a direct relation to the amount of heat transferred from latent energy of heat in the steam to kinetic energy of motion. Consequently, if in expanding steam we allow it to take several separate stages in its expansion corresponding lower velocities become most efficient. Thus in the 12,000 kilowatt turbines which seem to have become so popular on the Coast of late, as a rule five stages of expansion are utilized, thereby making it possible to have speeds of only 720 revolutions a minute.

Let us for a moment trace the course of the water entering the boilers until it again comes back to the boiler after having returned as water from the condenser of the turbine.

The water is first passed through a feed-water heater which as a rule is heated by means of the exhaust from the non-condensing auxiliary apparatus of the power station. It is next forced into the boiler or at times through an economizer. This economizer may perchance be located in the flue of the escaping gases, or as in the case of the Parker boiler, it may be directly located in the boiler itself. The water heated,

[1] This article comprises the Twentieth Lecture of a series appearing in these columns entitled "Primer of Applied Thermodynamics."

now to a temperature almost that of the saturated steam, enters the water drum of the boiler. From there it is fed through tubes which are exposed to the highest temperature of the furnace, returning to the steam drum as saturated steam or as water on the point of evaporation.

The saturated steam formed in the steam drum is next conducted through a superheater, which as a rule is in the form of tubes of small diameter located in the furnace proper although not exposed to the highest temperatures. The saturated steam passing through these pipes heated to a high temerature now becomes superheated and in the use of the turbine installation above referred to, it is usually taken to the turbine at a temperature of about 100 degrees above that of the temperature of the saturated steam for the pressure at which the turbine is designed to operate.

By means of properly designed asbestos lined steam pipes this superheated steam is taken directly to the steam turbine where it passes through nozzles, if the turbine be of the so-called impulse design, or through guides if it be of the so-called pressure design. The steam then at once emerges upon rotating blades or buckets, forcing these buckets to maintain a constant uniform rotation. Through all of this process the steam is expanding and as no heat is given out or transferred to the steam, the expansion is almost ideally adiabatic. In the case of the impulse type of turbine, the steam, by means of the nozzles through which it passes, is so expanded that it possesses an enormous kinetic energy.

The small particles of steam beating against the buckets of the turbine transform the major portion of their kinetic energy of motion to the rotating parts of the turbine which in turn generate electric energy. In the case of the pressure type however, the steam is not expanded in the stationary entering device but expands directly in the rotating buckets themselves, thereby causing rotation by pressure of the expanding steam.

When the steam has passed through a series of fixed nozzles or guides and then again through rotating guides or buckets it finally emerges into the condenser with all of its energy of motion almost completely absorbed At this point, cool water circulates through a mesh-work of steam pipes measuring literally miles in length. The steam now coming in contact with this constantly maintained cooling surface, condenses into water. A vacuum is thereby maintained which is still further perfected by means of a dry vacuum pump which exhausts from the condenser any remaining air or steam. By means of the wet vacuum pump, the water of condensation is now lifted out of the condenser into the so-called "hot well," where new water is being added from without in sufficient quantity to again supply the boiler in this continuous cycle of operations.

Let us analyze the construction of a typical modern turbine. The rotor consists principally of three drums (R), Fig. 1, of varying diameter, consisting of high intermediate and low pressure stages which have all end thrust neutralized by counter-balancing pistons (P). Pressures at various stages are communicated to the balancing pistons through equalizer passages (E). In general, this section represents the usual construction of all Parsons turbines. There is, of course, some departure made in different builds, chiefly in the arrangement of balancing pistons. This, however, is of no importance in the sizes in which the construction here illustrated is mainly used. Two self-aligning high-speed bearings (B) are used. Steam is introduced at (S) and controlled by the main admission valve (V) (to the right) admitting to the annulus (A). To provide for heavy overloads, steam under full pressure is supplied to the secondary valve (V) (to the left). A valuable provision is made to keep the governor valves in a constant vibrating motion, and in this way no friction of rest or sticking of the valves is to be overcome for any change in governor position. Thus the regulation of this turbine has always been above criticism. The exhaust passage is shown at (D). Water sealing glands at (W) positively prevent any inflow of air to the turbine, which would obviously impair the vacuum. New blading

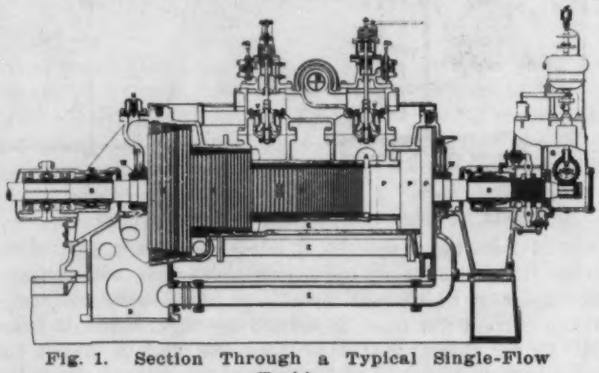


Fig. 1. Section Through a Typical Single-Flow Turbine.

formation and construction is plainly an important feature of tht turbine. Probably no other detail of the design has been the subject of such extensive experimentation as has been accorded the blading itself. Various blade shapes and methods of securing them to the rotor and cylinder have been exploited since the early turbines were built. Blading sections and lengths are now made so as to effect an almost ideal expansion of the steam passing through the turbine. In attaching the root of the blade, the problem is remarkably simple, the blade being provided with a small neck at the root and held by the compression forces of the caulked soft steel packing pieces. Under tension test, the blades will fail at some intermediate section before detaching at the root, due to the firm grasp of the packing pieces. Fastening of the blade tips has undoubtedly attracted the greater attention. Where there is a drop of pressure across each row of blades, it is preferable to maintain minimum clearances to reduce steam leakage. Some clearances may be actually beneficial to the economy of the turbine as it provides a passage for the water in the steam, permitting it to flow through without causing hydraulic friction on the tips of the moving blades, a theory advanced by experienced operators of steam turbines. A reinforcement of the outer ends is only necessary for long blades in order to avoid nodal vibration which might be set up in the steam currents, ultimately causing crystalization and failure of the blades. In the turbine shown, this is accomplished by a comma wire lashing which, on being clinched, establishes a stout abuttment between consecutive blades. Since the turbine cylinder has been made so symmetrical in design, distortion troubles have been removed.

The losses encountered in the operation of the turbine are four in number. In the first place, steam passing through the nozzles or guide vanes meets with a certain amount of friction in passing over the guiding surface. This friction reduces the amount of energy available for transference into kinetic energy. Secondly, we shall find that the actual angle at which the steam is allowed to enter the moving vanes and to depart from them is a most decided factor in the energy transferred to the rotating parts. After entering upon the moving vanes the steam meets again with friction in passing through them which is a loss that constitutes the third consideration and finally there are in the turbine the same losses due to friction which are experienced in any mechanical mechanism such as friction of bearings and journals, windage of rotation and the like.

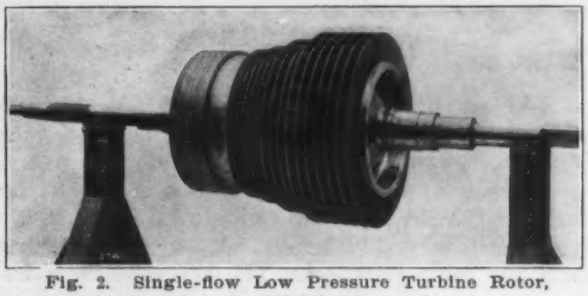


Fig. 2. Single-flow Low Pressure Turbine Rotor, 300 kw.

We learn from the theory of conservation of energy that, though energy may disappear in one form, it nevertheless is not destroyed, consequently if we sum up the different forms of energy in moving steam at one point in its movement and compare it to the energy at some other point, the energy summation in each case should be the same.

In Fig. 3, let p_1, v_1, T_1, E_1, K_1, H_1 be respectively the pressure, specific volume, absolute temperature, internal energy, kinetic energy and total heat per pound of steam as it crosses the entrance section of the nozzle in the steam turbine at A and let p_2, v_2, T_2, E_2, K_2, H_2 be the corresponding quantities at the exit section of the nozzle at E. We have previously learned that in addition to the internal energy of steam there is a certain amount of energy represented in external work which has been performed in the passing of the water into saturated steam. This amount of external work is found by multiplying the pressure times the specific volume. Hence the total amount of energy in the steam as it enters the nozzle at A is equal to $(E_1 + p_1 v_1 + K_1)$, in which we make a slight assumption by using v_1 instead of u in which u is the difference in volume between one pound of saturated steam and one pound of water. The difference between u and v_1 is however negligible for engineering computation. The energy at the emerging point of the steam at E is likewise $(E_2 + p_2 v_2 + K_2 + Q)$ in which Q is the amount of heat which has disappeared from the moving steam in the form of friction since the steam entered the nozzle in going from A to E.

Fig. 3. Assembled Nozzle, Wheel and Reversing Passage.

Since unit kinetic energy is equal numerically to the square of the velocity divided by 2g and since the two energy summations above are equal one to the other we now write the following equation:

$$E_1 + p_1 v_1 + K_1 = E_2 + p_2 v_2 + K_2 + Q; \text{ or}$$

$$H_1 + \frac{v_1^2}{2g} = H_2 + \frac{v_2^2}{2g} + Q$$

$$\therefore \frac{v_2^2}{2g} - \frac{v_1^2}{2g} = H_1 - H_2 - Q \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

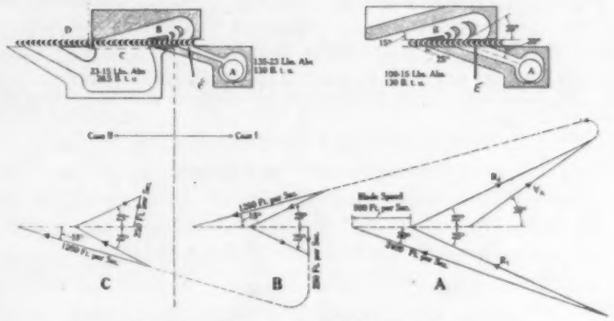


Fig. 4. Steam Velocity Diagram.

In the considerations of the turbine nozzle computation we may neglect certain quantities involved in this equation for the time being. Let us neglect $\frac{v_1^2}{2g}$, and Q. Hence we have $\frac{v_1^2}{2g} = H_1 - H_2$. Converting the right hand side of this equation into foot pounds in order to have our velocity in feet per second, we now have

$$\frac{v_1^2}{2g} = 778\ (H_1 - H_2) \text{ or } v^2 = 2 \times 32.2 \times 778\ (H_1 - H_2)$$

$$\therefore v_1 = 223.84 \sqrt{H_1 - H_2}$$

We are now able to compute the theoretic velocity of the steam emerging from the turbine nozzle and we shall find in the next lecture a correction to make to this theoretic velocity thereby taking account of the friction Q in order to arrive at the exact velocity. It is interesting to see the enormous velocities that the steam has in emerging from a turbine nozzle under ordinary temperature and pressure when but one stage of expansion is used in the steam turbine.

Before proceeding however to this computation it is necessary to review some of our principles of entropy in order to arrive at the proper value of H_2. This can be best brought out by illustration. Let us assume that we have a single stage turbine receiving steam at

150 pounds absolute and 600 degrees F. in temperature, which discharges the same into the condenser maintaining 2.0 lb., absolute pressure. In order to compute the value of H_2 it is necessary to know the quality of the steam as it enters the condenser. This we can only arrive at by taking into account our entropy equations.

By referring to Steam and Entropy Tables of Marks and Davis, we find that the total heat of steam under a pressure of 150 lb. absolute and 600 degrees F. temperature is 1316.6 B.t.u. Similarly by observing equal entropy relations we find that the total heat of the wet steam at 2 lb. absolute is 987.5 B.t.u. Hence the velocity of the steam issuing from the nozzle is

$$v = 223.84\ \sqrt{H_1 - H_2}$$

$$= 223.84\ \sqrt{H_1 - H_2} = 223.84\ \sqrt{H_1 - H_2} = 4060 \text{ ft. per sec.}$$

In the next lecture we shall look more carefully into this velocity relation and also into methods involving the computation of the quality or wetness of the exhaust steam.

Solution of Thermotwisters—Fifteenth Lecture.

1. A simple double acting engine receives steam at 75 lb. gauge and operates condensing with a 24 in. vacuum. The stroke is 48 in., the point of cut-off at 1/5th stroke,, the revolutions per minute of the crank, 95; the diameter of the cylinder bore 30 in. What is its horsepower?

$$P_1 = 75 + 14.7 = 89.7,\ r = 5,\ L = \frac{48}{12} = 4,\ A = \frac{3.1416 \times 30^2}{4} = 706.9$$

$$N = 2 \times 95 = 190$$

$$P_1 \frac{1 + \log_e r}{r} = 89.7 \frac{(1 + \log_e 5)}{5} = \frac{89.7 \times 2.609}{5} = 46.8$$

$$P_b = \frac{30 - 24}{2} = 3 \text{ lb. abs.}$$

$$\therefore P = 46.8 - 3 = 43.8$$

$$H.P. = \frac{PLAN}{33000} = \frac{43.8 \times 4 \times 706.9 \times 190}{33000} = 713. \quad \text{Ans.}$$

2. The above engine has a clearance of 1/9th stroke and the point of compression takes place 5/6th stroke on the return. With this added information compute more accurately the horsepower of the above installation.

$$P_1 = 75 + 14.7 = 89.7,\ L = \frac{48}{12} = 4,\ A = \frac{3.1416 \times 30^2}{4} = 706.9$$

$$c = \frac{48}{9 \times 12} = .44 \quad X = \frac{48}{6 \times 12} = .67,\ l = \frac{48}{5 \times 12} = 0.80$$

$$P_b = \frac{30 - 24}{2} = 3$$

$$E = P_1 (1 + c)\ [1 + \log_e \frac{L + c}{l + c}]$$

$$= 89.7\ (0.80 + 0.44)\ [1 + \log_e \frac{4 + 0.44}{0.80 + 0.44}]$$

$$= 89.7 \times 1.24\ [1 + \log_e \frac{4.44}{1.24}] = 89.7 \times 1.24 \times 2.2754 = 252.4$$

$$B = P_b (L - x) = 3\ (4.00 - 0.67) = 3 \times 3.33 = 10.00$$

$$C = P_b (x + c) = 3\ (0.67 + 0.44) = 3 \times 1.11 = 3.33$$

$$D = P_1 c - P_b (x + c)$$

$$= 89.7 \times 0.44 - 3\ (0.67 + 0.44)$$

$$= 89.7 \times 0.44 - 3 \times 1,11 = 39.44 - 3,33 = 36.11$$

$$\therefore B + C + D = 10.00 + 3.33 + 36.11 = 49.44$$

$$\therefore A = 252.40 - 49.44 = 202.96$$

$$H.P. = \frac{PLAN}{33000}$$

$$= \frac{202.96 \times AN}{33000} = \frac{202.96 \times 706.9 \times 190}{33000} = 827. \quad \text{Ans.}$$

SUMMARY OF PROGRESS IN RECLAMATION.

The following projects have been undertaken by the U. S. Reclamation Service since its inception nine years ago:

Arizona has received	$13,640,000
Colorado has received	9,865,000
Idaho has received	19,719,000
Nebraska-Wyoming have received	10,280,000
Montana has received	15,695,000
Nevada has received	6,380,000
New Mexico has received	10,250,000
North Dakota has received	880,000
Oregon has received	6,060,000
South Dakota has received	3,000,000
Utah has received	2,063,000
Washington has received	11,558,000
Wyoming has received	6,750,000

The act of Congress approved June 17, 1902, known as the "reclamation act," set apart as a fund for the reclamation of arid lands all moneys received from the sale of public lands in certain of the Western States and Territories, excepting the 5 per cent of the proceeds of such sales set aside by law for educational and other purposes. The actual receipts from this source to June 30, 1910, were $65,584,801.32, and the estimated total receipts to June 30, 1911, including $213,998.57 from the sale of town-site lots, are $71,717,990.16. The net investment of this fund in reclamation works on June 30, 1911, amounted to $60,940,834.08.

No new projects have been undertaken since March 4, 1909, but prior to that date 32 primary projects had been undertaken, the net investment in which on June 30, 1911, amounted to $59,989,158.46, as is shown in the following table:

NET INVESTMENT IN RECLAMATION PROJECTS TO JUNE 30, 1911.

State and Project.	Net Investment
Arizona: Salt River	$ 9,164,437.56
Arizona-California:	
Colorado River	43,659.73
Yuma	4,313,868.21
California: Orland	490,004.53
Colorado:	
Grand Valley	83,683.71
Uncompahgre	4,509,697.63
Idaho:	
Boise	4,515,525.06
Minidoka	3,741,216.57
Kansas: Garden City	380,030.09
Montana:	
Huntley	853,427.76
Milk River	911,487.99
Sun River	768,493.35
Lower Yellowstone	2,922,442.00
Nebraska-Wyoming: North Platte	5,130,965.75
Nevada: Truckee-Carson	4,103,346.71
New Mexico:	
Carlsbad	571,181.17
Hondo	349,212.20
New Mexico-Texas: Rio Grande	290,746.75
North Dakota: Missouri River pumping	845,474.73
Oklahoma: Cimarron	8,873.17
Oregon:	
Central Oregon	40,416.67
Umatilla	1,206,391.31
Oregon-California: Klamath	1,812,476.07
South Dakota: Bellefourche	2,683,345.04
Utah: Strawberry Valley	1,214,411.90
Washington:	
Okanogan	539,866.49
Yakima	4,905,181.83
Wyoming: Shoshone	3,580,249.28
Total	$59,989,158.46

In addition, there had been invested in secondary projects, June 30, 1911, $586,988.94; in town-site development, $12,997.05; in Indian irrigation (reimbursable), $317,392.23; and for general expenses, $34,297.40, making a grand total of $60,940,834.08. In view

of the immense areas of land included, the magnitude and expense of the engineering work necessary to provide for their reclamation, and of the importance to the waiting settler and land owner that water be applied to the land and reclamation effected as soon as possible, the efforts of the Department have been directed toward the completion of projects already undertaken rather than the search for or undertaking of new projects. The following table contains a summary of the results of the reclamation work from June 30, 1902, to June 30, 1911:

SUMMARY OF RESULTS OF RECLAMATION WORK, JUNE 30, 1902, TO JUNE 30, 1911.

Material excavated ..... cubic yards..		77,148,712
Class 1 ..... cubic yards..	67,658,616	
Class 2 ..... cubic yards..	5,136,331	
Class 3 ..... cubic yards..	4,353,765	
Volume of storage dams ..... cubic yards..		7,192,787
Volume of dikes ..... cubic yards..		3,338,532
Available reservoir capacity ..... acre feet..		4,747,770
Number of tunnels		68
Aggregate length of tunnels ..... feet..		101,365
Canals carrying less than 50 second-feet..... miles..		4,341
Canals carring from 50 to 300 second-feet.... miles..		942
Canals carrying from 300 to 800 second-feet.. miles..		387
Canals carrying more than 800 second-feet.... miles..		291
Canal structures costing less than $500.....		22,226
Canal structures costing from $500 to $2000.....		847
Canal structures costing over $2000.....		529
Number of bridges		2,223
Aggregate length of bridges..... feet..		47,310
Riprap ..... cubic yards..		336,056
Paving ..... square yards..		344,891
Cement used ..... barrels..		1,245,827
Concrete ..... cubic yards..		1,066,310
Roads ..... miles		570
Telephone lines ..... miles..		1,694
Telephones in use		724
Buildings erected		548
Offices	65	
Residences	258	
Barns and storehouses	225	
Area of lands for which water can be supplied..acres..		1,025,609
Acreage included in projects now under way.....		3,101,450

MUNICIPAL ENGINEERING IN CHINA.

BY CONSUL C. L. L. WILLIAMS, SWATOW.

There is considerable interest among the local Chinese in municipal improvement. During 1909 and 1910 a new electric-light plant was erected, the work being in charge of Arnhold Karberg & Co., a German firm. The machinery consists of 4 Young's Lancashire boilers, 2 Babcock & Wilcox water-tube boilers, 2 Worthington feed and fire pumps, 1 Cameron (New York) surface condenser, 4 Bellairs & Morcam (Manchester, England) self-lubricating engines, and 4 direct-current generators with switchboard (Allgemeine Elektricitats-Gesellschaft, Berlin). The city is wired with mains feeding submains through section boxes Consumers are supplied with 220 volts and the number of lamps installed at the beginning of 1910 was about 4000. All streets are lighted by 25-candlepower lamps at intervals of about 80 feet. The price to consumers is fixed at 30 cents Mexican (about 13 cents American) on the first 1½ units and 20 cents (8 2/3 cents American) on each succeeding unit per lamp per month.

During 1910 work was started on the local waterworks system. Lee & Orange of Hongkong are the architects for the buildings and MacDonald & Co., also of Hongkong, are the engineers. The water will be taken from the River Han, about 10 miles above Swatow. The pumping and filtering plant will be at the intake and will consist of 4 settling tanks, each of 1,200,000 gallons capacity, 4 filter beds, each of 260,000 gallons capacity, 1 covered-in service reservoir of 800,000 gallons capacity, and the engines, boilers and pumps. The main from the intake station to Swatow will be a 12-inch cast-iron pipe, about 6¾ miles long, and the quantity of water delivered at Swatow 3.33 cubic feet per second. At Swatow will be a water tower from which the street mains will be supplied. The cost of the work is estimated at $325,500 gold However, owing to unsettled conditions in China, the construction of the works is indefinitely postponed.

Had there been any American engineering firms on the spot when these projects were mooted it is quite possible that they could have received some share When it is remembered that the Chinese promotors of these undertakings are without technical knowledge, it is obvious that no engineering firm can hope to secure such work through correspondence.

American firms desiring to enter the field in South China should make their headquarters at Hongkong, from where all southern outports are easily covered as occasion requires.

LOW POWER RATES IN URUGUAY.

The President of Uruguay, in an official decree, calls attention to his proposition to establish State control and centralized management of all the electric plants in the republic, and lays down the following reduced tariff per kilowatt-hour for electricity for power and heating: Up to 1000, 5½ cents; 1000 to 2000, 4 cents; 2000 to 3000, 3 cents; more than 3000 2 cents.

While it is estimated that this reduction in tariff will result in a decrease in the gross earnings of the Usina Electrica of Montevideo of some 43,000 pesos ($44,462), it is believed that the plant can still be run at a profit. This reduction in the cost of electricity in Montevideo makes the rate in this city in general the lowest of any municipality in South America.

LOS ANGELES AQUEDUCT HYDROELECTRIC PROJECT.

The city of Los Angeles has recently approved a bond issue amounting to $357,367 to complete the equipment of the hydroelectric project to be operated in connection with the 250 mile aqueduct by which the city water is brought from Owens Lake near the Yosemite National Park.

The generating equipment will be installed at Power House No. 1 located at San Francisquito, 47 miles from Los Angeles, to which point current is sent at 60,000 volts.

In the power house, there will be installed three 9375 k.v.a., 6600 volt, 50 cycle, three-phase water wheel generators running at 200 r.p.m.; and two 250-kw., 250 volt direct current water wheel generators used as exciters; ten 3150 k.v.a., single-phase, 50 cycle oil insulated water cooled transformers for raising the generator voltage (6600) to that of the transmission, 60,000.

In the substation there will be installed nine 5000 k.v.a. single-phase, oil insulated water cooled transformers for stepping down the transmission voltage to either 33,000 or 16,000 for secondary distribution. The contract for the entire equipment was awarded to the Westinghouse Electric & Manufacturing Company.

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Great Western Power Company Announcement

The announcement of the Great Western Power Company, found in our last issue, is of interest to the electrical fraternity on the Coast. The continual development of enormous western water powers shows the implicit confidence held in high financial circles regarding the substantial growth of our western empire. Needless is it to say, that this confidence is not misplaced.

A careful study of the growth of our nation during the past decade fully emphasizes the section of our country, for which the future has most in store.

The reclamation projects of the future must largely look to the pumping of water in the solution of their distributing systems. The power supply required, although economic in unit reclamation, when totaled for the millions of acres susceptible to irrigation will unquestionably utilize every available source of hydroelectric energy capable of reasonable development in the West.

Polar Co-ordinates

Much confusion has always befogged the reader's mind when attempting to compute instantaneous values in alternating electric circuits. The ordinary sine wave if plotted to scale shows to the eye how instantaneous values may be combined when two or more are impressed upon the same circuit.

Alternating currents are, however, measured in effective values instead of instantaneous values. That is, the square root of the sum of the squares of the instantaneous values is taken as the true value, in practice. A reading in alternating current units indicates the amount of alternating current, for instance, which would be necessary in the heating of a wire the same amount that a direct current of the same value would accomplish.

The polar co-ordinate, while receiving some attention from engineers, has been mostly relegated to the back-ground, due to the fact that it has always been thought it could not be used for instantaneous values. Elsewhere in these columns will be found an article by Mr. A. L. Menzin on the Graphical Analysis of Alternating Current Phenomena. Mr. Menzin by means of very simple illustrations brings out the ease with which not only maximum or even effective values in alternating currents are correctly shown on the polar graph but in fact, instantaneous values are also shown in remarkably lucid form. A deeper study into polar co-ordinate representation will unquestionably bear much fruit in the further clearifying of the graphical picturing of complicated alternating current phenomena.

Apathy of California in Reclamation

Elsewhere in these columns will be found a summary of the reclamation projects which have been undertaken by the Federal Government and also will be found the net progress in expenditure and accomplishment which has been made.

A careful analysis of this summary shows a most surprising condition of affairs. The great commonwealth of California, the second in size in the Union, known the world over for its irrigation enterprise and

advance, stands awkwardly alone at the foot of the column. It is indeed true that a first glance at the tabulation shows somewhat more favorably for California by counting as California enterprises the Oregon-California and Arizona-California projects. Analyzing these two projects, however, we find that both, so far as the California side of the undertaking is concerned, will total less expenditure than $250,000. The sole undertaking which may be credited to California is that of the so-called Orland project, which totals $620,000 in all and which shows a net expenditure to date of $490,004.53.

The cause for such discrepancy is solely due to the apathy of California citizens. Attend the National Irrigation Congress if you will, and contrast the attendance and vital interest of other states to the cold indifference of California as shown in her usual half dozen delegates.

Montana, one of the sparsely settled states in the Union, has secured favorable action on over $15,000,000 in reclamation appropriations. California, accustomed to parade its irrigation prowess to the world, secures $620,000. No one can visit the arid lands of central California or even the sun-lit deserts of the southern portion of the state, without seeing in this beautiful stretch of fertile soil, a possibility of reclaiming a million and a half acres of land. Such enterprises are beyond the scope of private capital, as national funds are necessary for liquidating such vast expenditures.

The enterprise and energy of the great "poppy state" should for one season be devoted to promotion of some of her best arid land projects. No one reclamation enterprise hitherto undertaken for other states should be jeopardized or cut down in appropriation, but immediate steps should be taken by that great commonwealth to see to it that a reasonable appropriation be expended in her behalf to assist in the development of her vast arid kingdom.

Engineering Opportunities in China

The burning of forty maidens, pure and undefiled, at the funeral pyre of Jenghis Khan to satisfy the morbid passions of the world's greatest human scourge, who in the thirteenth century came forth from the wilds of Mongolia and nearly swept European life from the face of the earth, is a frightful illustration of what Chinese civilization has been to the human race.

The invention of powder, the manufacture of glass, the art of printing, and nearly all the other great triumphs of modern advance are claimed by the Chinese so far as priority of invention is concerned, and yet to what useless and inferior applications have they put these great forces of modern progress.

Two hundred and fifty million human hearts, a number in magnitude almost beyond conception, throb and pulsate in the "great flowery kingdom," and yet stagnation has so enthralled its people that to review the inferior progress such vast numbers have made affords a striking picture to the thinking mind. With this enormous population, however, and with undeveloped resources, inconceivable in their gigantic proportions, the Chinese Empire presents today the greatest field for rapid industrial growth and internal development of any nation on earth.

Those of us who have, day by day, followed the progress of affairs in China, cannot help but be impressed with the contents of the manifesto issued by President Sun Yat Sen at Shanghai under date of January 5th last. China has in the past had her revolutions, slaughtered her millions, only to sink again into lethargy and stagnation. The revolution of today, nevertheless, seems to be so impregnated, so permeated through and through with western ideas and civilization that the careful student following the trend of recent events can but see in this uprising a tendency toward an immediate and complete upheaval of old ideas and an installation of the new. Indeed, it is stated in the republican manifesto, above alluded to, that if the revolution succeeds, it "will remodel the laws, revise the civil, criminal, commercial and mining codes, reform the finances, abolish the restrictions on trade and commerce, and insure the development of better relations with foreign peoples than have ever been maintained before." Continuing further it states that the supporters of the republic cherish the hope of co-operating in the great and noble task of building up the civilization of the world, and they put themselves on record as stating that the Manchus have retarded the creation of industrial enterprise and rendered impossible the development of natural resources.

The cueless Chinaman of the future presents a picturesque yet impressive figure. It seems that the leaders of the struggle for the establishment of a republic are largely those who have received their education among the foreign nations of the world. Secret orders have been maintained by them for the past twenty years for the sole purpose of protecting their ideas throughout the civil, military, and commercial life of the empire. How successful they have been in their silent work is daily unfolded in the continued and successful progress of the Chinese insurrection.

Especially for the engineer of our West, the opportunities now soon to be afforded in the awakening of China are unparalleled in history. The remitting of the Boxer indemnity by the United States has offered an opportunity for using this money by the Chinese officials to educate their most brilliant young men. This award, in fact, was set aside by the Chinese Government and devoted for educational purposes. Thousands of their young men have entered the educational institutions of the United States, and especially have the colleges and universities of our western coast been patronized most generously.

Follow the news of the day, and many of the names set forth as leaders in the present upheaval, from cabinet officers down, will be found in the list of graduates or former students of the University of California, Leland Stanford Jr. and other western institutions. Even now these young men have in contemplation the introduction of our methods in the remodeling of Chinese engineering growth.

Our Pacific ports turn with outstretched arms toward the Orient. Commercial bodies as well as our western engineers should be alive to the immediate opportunities to be found. In the acting, then, of the Oriental engineering drama immediately ahead, let us be alert and take as our entering cue into the land of the celestials the nation-wide abandonment of this time-honored hair appendage.

PERSONALS.

M. C. Lord has been made engineer and sales manager for David Dow & Son, of Seattle, Washington.

R. D. Holabird, president of the Holabird-Reynolds Company, has returned to San Francisco after visiting Los Angeles.

H. E. Sanderson, Pacific Coast manager for the Bryant Electric Company, has been at Los Angeles during the past week.

Benj. J. Weeks, commissioner of light and power, Seattle, has resigned. Mr. Weeks gives as his reason his dislike for politics.

B. C. Carroll, general agent of the Pacific Telephone & Telegraph Company, is making an extensive trip through the Northwest.

L. H. Gardner, of the code department of the Western Union Telegraph Company, has arrived at San Francisco, from New York, on a tour of the Pacific Coast.

A. L. Rogers of Waterville, Wash., a regent of the State University, has declined the offer of a position on the Public Utilities Commission of the State of Washington..

A. J. Myers, district manager of the Wagner Electric Manufacturing Company, is at Los Angeles on his return trip after attending the annual managers' meeting at St. Louis.

William Clayton, who acts as general manager of John D. Spreckels' interests at San Diego, including the San Diego Electric Railway system, was a recent San Francisco visitor.

H. F. Gronen, the project engineer of the Seattle municipal ownership company, will assume, until April, the duties of commissioner of light and power made vacant by B. J. Weeks.

F. E. Trask, consulting civil and hydraulic engineer of Los Angeles, has removed his offices from rooms 421-425 Homer Laughlin Building, to rooms 616-624 Union Oil Building.

C. O. Poole of Manifold & Poole, the Los Angeles electrical engineers who have supervision of the Southern Sierras Power Company's new development, is at San Francisco on hydroelectric business.

Ralph L. Phelps, Pacific Coast manager for the Safety Insulated Wire & Cable Company, is expected to return to his office at San Francisco about February 20, after spending a month at New York.

Garnett Young, general manager of the Telephone-Electric Equipment Company, has returned to San Francisco from Southern California, where he spent a week in visiting the Los Angeles office, of which R. J. McHugh is manager.

J. Q. Brown, chief engineer and purchasing agent of the Oakland Railway Company, has returned to Oakland after completing an extensive Eastern trip in the course of which he visited the leading factories.

R. F. Oakes, president of the American Ever Ready Company, with headquarters at Factory No. 8, San Francisco, will motor down to Del Monte on Saturday, February 17, with his family and will remain over for the Electrical Jobbers' golf tournament, opening February 22.

F. E. Blanchfield, who was formerly Northwest salesmanager for the American Ever Ready Company, has been appointed sales manager at San Francisco, under president R. F. Oakes of the Pacific Coast department.

R. B. Dougall, who was for eleven years connected with Paul Seiler & Co., has joined the sales force of the Pacific States Electric Company. M. L. Scobie, formerly of Chicago, has also joined the sales department of this house.

Rex T. Stafford, who has been connected with the San Francisco office of the Allis-Chalmers Company for several months past, left for Puget Sound last Sunday, with his family, and will, in the future, be one of the salesmen in the electrical department at the Seattle office.

Joseph Blethen, manager of the Seattle Daily Times, and president of the Seattle Carnival Association, was the guest of honor of the Jovian Electrical League at their Seattle luncheon, on February 8th, at the Butler Hotel.

H. V. Carter, president of the Pacific States Electric Company, has just returned from the Northwest. Mr. Carter reports that prospects through this promising territory are most encouraging. Business men are optimistic and the outlook for a successful season was never of a brighter hue.

L. R. Wiley, a hydroelectric engineer who has been identified for several years with Tuolumne county power enterprises, which are now controlled by John Hays Hammond, is at San Francisco, after spending some time in the East on business connected with power sites in Northern California.

Wynn Meredith, Pacific Coast manager, and Francis Blossom, a member of the firm of Sanderson & Porter, of New York, arrived at San Francisco from the Northwest last Saturday. Mr. Blossom leaves this week for the East and expects to stop over at Los Angeles and Trinidad, Colorado.

H. W. Clapp has been appointed assistant electrical engineer of the Southern Pacific Company under A. H. Babcock, the chief electrical engineer. Mr. Clapp has had charge of the electrical construction work on the company's local lines in Alameda county, which have been electrified during the past year.

Theodore B. Comstock, secretary and chief engineer of the Board of Public Utilities in Los Angeles, will soon retire from the position and will be succeeded temporarily at least by Thomas Foulke, a member of the board. The probabilities are that Charles E. Warner, at the present time investigating the aqueduct, will finally occupy the position.

R. S. Buck, the member of the firm of Sanderson & Porter who managed the construction of the Stanislaus plant, will arrive at San Francisco, Feb. 20, to remain permanently. Buck's presence is necessary on account of increase of activities in the West. Mr. Buck, together with Wynn Meredith, will constitute two members of the firm of Sanderson & Porter, with permanent headquarters at San Francisco.

Clarence F. Clewell, who for the last two years has been in charge of the design and installation of the extensive lighting work at East Pittsburgh shops of the Westinghouse Electric & Manufacturing Company, has recently been transferred to the sales department of the electric company and is now engaged in illuminating engineering work in connection with detail and supply department.

Geo. E. Dow, general manager of the Geo. A. Dow Pumping Engine Company, left San Francisco this week for an extensive European trip during which he will be accompanied by an engineer thoroughly familiar with the Diesel engine. Mr. Dow proposes to manufacture these engines on the Pacific Coast. Now that the Panama Canal is nearing completion San Francisco is destined to be a great manufacturing center as well as a consumer of manufactured articles.

J. W. Churchill, president, and J. P. Churchill, vice-president of the California and Oregon Power Company, which has just taken over the Rogue River Power Company, the Siskiyou Electric Power and Light Company and a number of other power plants in the two states, have been spending a few days at San Francisco. They are closing contracts for the first generating unit for their new development on the lower Klamath river, which has an ultimate capacity of about 100,000 kw.

W. H. Storms, the recently appointed California State Mineralogist, is now collecting data relative to mineral production for 1911, as required by law. The result of this work, published in an annual report, helps greatly in advancing the varied mineral interests of the State. The greater part of the information required is obtained by corresponding with the owners and operators of mineral property. Many

in this locality probably have received inquiry blanks from the State Mining Bureau regarding the output and progress of work in the year 1911. Those who have received such, are urged to answer them at once.

ELECTRICAL CONTRACTORS' NOTES.

T. C. Hobreck, secretary of Sacramento Local No. 3, was at San Francisco on business during the past week.

Paul Butte, of the Butte Engineering and Electric Company, will make a trip to the Pacific Northwest during the coming week.

The office of the secretary of the California State Association of Electrical Contractors has been moved to Room 1408, Metropolis Bank building.

W. S. Hanbridge, secretary of the Electrical Contractors' Association, spent Monday in Palo Alto and San Mateo looking after the contractors' interests.

Hetty Bros. have removed their electrical supply house from 357 Ellis street to 372 Ellis street, their permanent quarters at San Francisco.

The Joshua Hendy Company has secured a contract for ornamental cast-iron electric light posts for use at San Jose, where a development league has arranged for better illumination of certain business streets.

Lange & Bergstrom have been awarded the contract for putting up the new building for the Sharon Estate on the corner of New Montgomery, Jessie and Stevenson streets. The sub-contracts will be let in a few days. The entire ground floor has been leased to the General Contractors' Association, and it is probable that this fine office building will be the office home of most of the building contractors.

IN MEMORIAM.

Arthur W. Ballard, president and general manager of the Pacific Gas & Electric Company of Phoenix, Arizona, died at that city on February 8th from a self-inflicted gunshot wound. Mr. Ballard had suffered great pain during the past few months and had been dreading a necessary operation for gall-stones, and it is believed that the ensuing despondency caused the act.

Mr. Ballard was 43 years of age, a native of London, England, coming to America with his parents in 1870. He received his education in Canada and came to the Pacific Coast in the early '90s, where he entered the employ of the General Electric Company, later being made manager of the company's Los Angeles office. After twenty years' service with the General Electric Company Mr. Ballard resigned his position about two years ago to look after his private interests.

At the time of his death Mr. Ballard was president of the Pacific Gas & Electric Company, Alhambra Brick and Tile Company and Phoenix Machine and Cold Storage Company, all of Phoenix, Arizona, and the Santa Maria Gas & Electric Company. He had investments in several other large corporations. He was a member of many prominent clubs and a man of remarkable executive and business ability and possessed the charm of a personal magnetism and buoyant disposition which won for him the abiding friendship of a host of prominent men throughout the cities and towns of the Pacific Coast.

SAN FRANCISCO SECTION A. I. E. E.

An interesting meeting of the San Francisco Section of the A. I. E. E. is in store for the members at the next meeting, Friday evening, February 23, Home Telephone Building. Sam L. Naphtaly, general manager of the Great Western Power Company, will present a paper on the recent submarine cable crossing of San Francisco Bay, the first successful submarine power cable to transmit hydroelectric power into San Francisco.

N. E. L. A. NEWS.

The Residence Business Committee of the Commercial Section of the National Electric Light Association met for its second meeting on January 15th and 16th. The meeting was attended by Messrs. J. F. Becker, chairman; G. B. Griffin, E. A. Norman, G. C Osborne, F. D. Pembleton and N. H Boynton, secretary. This committee has taken upon itself the very important work of compiling data, information and literature which will assist central station companies to increase their residence business and to make it more profitable to them. In the search for accurate data each member of the committee is doing personal work, they are also soliciting the assistance of all central station companies. This publication is to be a 24-page and cover 3x6 booklet which many central stations will use in their campaign for residence business.

PORTLAND SECTION OF N. E. L. A.

Over 100 members of the National Electric Light Association employed by the various public service corporations having headquarters in Portland, Oregon, have organized the Portland Section of the N. E. L. A. The following companies are represented: Portland Railway, Light & Power Company, Pacific Power & Light Company, Mt. Hood Railway & Power Company, General Electric Company and Westinghouse Electric & Manufacturing Company.

The first regular meeting of the Portland Section was held in the Auditorium of the Electric Building on Tuesday evening, February 6. At that time, Mr. S. G. McMeen, recently elected president of the Mt. Hood Railway & Power Company, addressed the section on the subject of "A Few Fundamentals." Mr. McMeen's talk was intensely interesting and portrayed the personal side of a number of prominent scientists and inventors. After his address the Section was entertained by a number of amateur entertainers, music being furnished by the Electric Club orchestra.

The officers of the Portland Section are: Chairman, A. S. Moody, General Electric Company; Vice-Chairman, A. C. McMicken, Portland Railway, Light & Power Company; Secretary, Lewis A. McArthur, Pacific Power & Light Company; Treasurer, R. S. Carroll, Portland Railway, Light & Power Company; Executive Committee, C. E. Groesbeck, H. M. Byllesby & Co.; O. B. Coldwell and C. C. Turlay, Portland Railway, Light & Power Company.

ELECTRICAL SUPPLY JOBBERS' ASSN. MEETING.

The Electrical Supply Jobbers' Association of the Pacific Coast is about to hold a convention at Hotel Del Monte on February 22, 23 and 24, 1912.

BOOK REVIEW.

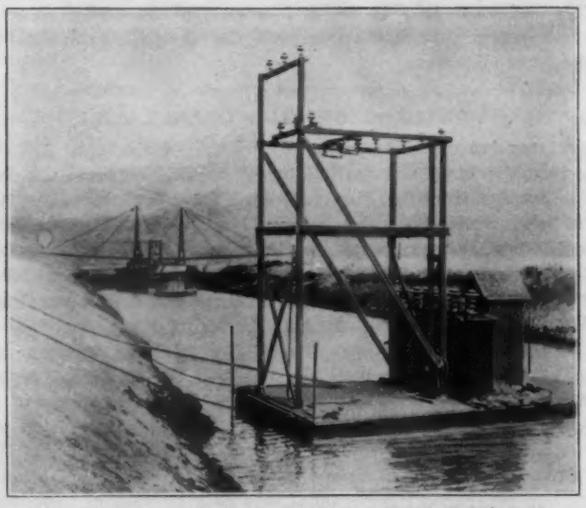
Mill and Factory Wiring. Electrical installation manuals. By manuals. By J. H. Johnson, A. M. I. E. E. Size 4x6½ inches; 135 pages; illustrated; clear type; strong paper; durable cloth binding. Published by D. Van Nostrand Co., of New York and for sale by Technical Book Shop, 106 Rialto Bldg., San Francisco. Price Seventy-five cents.

This book contains nine chapters which cover a discussion of the reflective power of substances, open arc lamps, enclosed arc lamps Crompton-Blondel flare lamps, excello flame lamps, illumination requirements of various industries, and current for bioscope lamps. An illustration in cross-section is shown for each characteristic lamp and a description of its working principles follows in simple style. Many hints are then given for the proper installation and use of the lamp, together with its accessories. The discussion on methods of suspension and switchgear is interesting and profitable, which coupled with the useful tables to be found throughout on pertinent data make it of much practical value.

INDUSTRIAL

HIGH VOLTAGE OUTDOOR TRANSFORMERS.

There is a steady and growing demand in small towns, and in various small industrial plants located near high voltage transmission lines, for outdoor transformers to distribute electric power directly from the high voltage line. This demand has led to the development of high voltage outdoor transformers, which is one of the comparatively recent advances in transformer design. There are a great many places where a small amount of power can be sold and yet where it is not economically feasible to install a substation. What is required is a transformer that can be mounted on a platform in any convenient manner, and connected to the transmission line without any provision for protection from the weather.



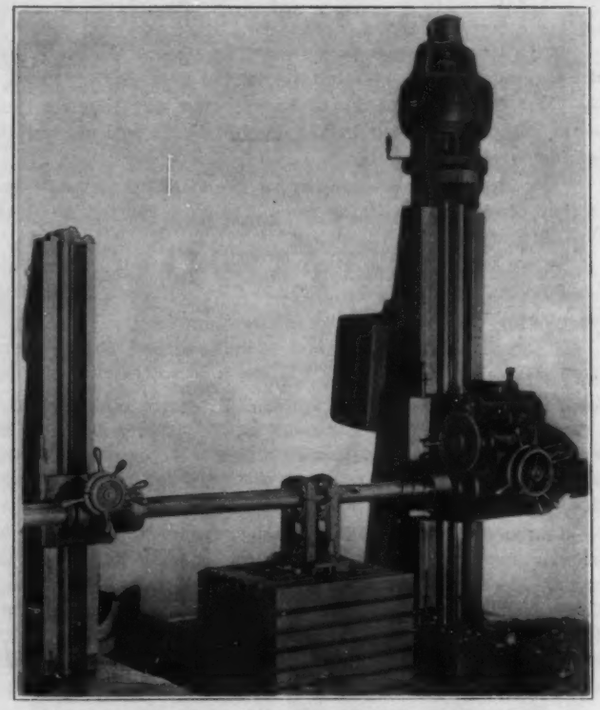
40 k.v.a. single-phase 50-cycle 33,000-22,000-volt Outdoor Transformer installed on float for operating dredges used in the construction of the Los Angeles Aqueduct.

An interesting installation of outdoor type transformers is shown above, which illustrates three 40 k.v.a. single-phase transformers installed on a float for three-phase service. These transformers were used in the construction of the Los Angeles Aqueduct. This method was found very convenient as the float was readily towed from place to place and anchored as the work progressed. Connections were made to an adjacent high tension line and the voltage was stepped down for use on an electrically operated dredge.

VERTICAL MOTOR DRIVE FOR BORING MACHINE.

By the use of individual electric drive, the machines may be located in the most convenient places for the work they are to perform, rather than in a row and driven from one line shaft. The economy and flexibility of individual motor drive cannot be too greatly emphasized, since this form of furnishing power has been largely responsible for the increased output of many varied industries.

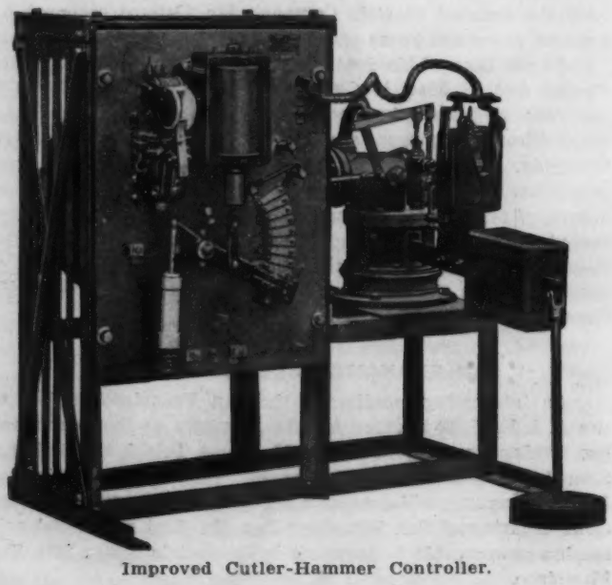
A particularly interesting and somewhat unique example of the manifold advantages of individual motor drive, applied to machine tools, is shown by the accompanying illustration. This horizontal boring machine is built by the Rochester Machine Tool Company of Rochester, New York. The motor is a 5 h.p. vertical type R, made by the Westinghouse Electric & Manufacturing Company of East Pittsburg, Pa. The method of mounting the motor on the top of the column, as illustrated, has proved particularly satisfactory in securing maximum efficiency and it has been surprising to many that motors of such small capacity should prove ample for the heavy work accomplished.



Rochester Horizontal Boring Machine Driven by a 5 H.P. Type R Westinghouse Vertical Motor.

NEW CUTLER-HAMMER CONTROLLER SOLVES HYDRAULIC ELEVATOR PUMP PROBLEM.

Central stations with considerable power loads must have power engineers who make thorough surveys and careful calculations of electric power applications. Mr. J. C. Par-



Improved Cutler-Hammer Controller.

ker, electrical and mechanical engineer of the Rochester Railway & Light Company, has an engineering force that has built up a motor load that is typical of what can be done by the right methods. Every effort is made to give the customer an equipment which will be economical in current consumption, have low peak demands and be at the same time profitable to the company.

The case of a customer using a motor to drive a rotary screw pump on an hydraulic elevator system is a recent example of this company's methods. The outfit in use was noisy, not competent to maintain sufficient pressure during the rush hours of the day and being of low efficiency caused a light power consumption. The problem was similar to two others that had been previously solved by the engineers of the company.

A triplex pump in this case was substituted delivering 200 gallons per minute and was driven by a 13 h.p. 220 volt variable speed motor The controller, furnished by The Cutler-Hammer Manufacturing Company of Milwaukee and illustrated herewith regulates the motor automatically so that when the elevator service is light, the pump is run at its slowest speed, but as service grows heavier, the motor speed is increased automatically by the controller and more water is pumped to meet the demand. The customer is saving $600 per year, which is 40 per cent of the cost of the new controller, pump and motor. The power rate is better because the controller maintains a uniformly tank pressure and sudden and high current demands do not occur. The controller used in this case is of different construction than the standard line having the regulating resistance mounted on the back and the automatic starter on the front of the panel, making it very compact.

A NEW CRANE CONTROLLER.

The well known "grindstone" type of controller used extensively in connection with direct-current motors operating cranes, hoists, steel mill machinery, etc., has proven eminently satisfactory. It has recently undergone a refinement, however, which will still further increase its value by simplifying its construction and increasing its durability.

Improved Crane Controller.

As shown in the illustration, the controller consists essentially of a cast iron frame on which is mounted a stationary disc carrying the contact pieces and cross connections. Pivoted to the center of the disc is the switch arm with four brushholders. The resistors can either be mounted on the frame or separate.

As a result of a series of experiments, the Westinghouse Electric & Manufacturing Company has recently placed on the market controllers of this type in which the disc is made of concrete instead of stone.

Fig. 1 shows the front view of the new concrete "grindstone" controller. In this particular piece of apparatus the resistors are separate and not shown. The contact pieces are attached to the disc by screws in the same way as in the older type, and are as easily removable. A blowout coil of asbestos insulated wire is mounted on each brushholder to disrupt the arc formed in opening circuits.

H. W. JOHNS-MANVILLE COMPANY SOLE SELLING AGENTS FOR I. P. FRINK REFLECTORS AND ILLUMINATING SPECIALTIES.

The H. W. Johns-Mansville Company, already well known in the lighting field by reason of their J-M Linolite System of illumination, have acquired the sole selling agency for the entire products of I. P. Frink.

"Frink" reflectors and fixtures need no introduction to the lighting trade and consumers throughout the country, and this arrangement means that the H. W. Johns-Manville Company will be in position to design and sell lighting systems for every known form of artificial illumination.

An engineering department will be maintained along very extensive lines. This department will maintain a corps of engineers throughout the United States and Canada, and be equipped to place data and recommendations in the hands of all interested in any subject pertaining to illumination.

TRADE NOTES.

The Ohio Brass Company of Mansfield, Ohio, has distributed during the past month their attractive Bulletin No. 1, of Vol. 7, which is devoted to electric railway and mine haulage material.

The General Electric Company has sold to the Honolulu Rapid Transit Company, for its traction lines in the Hawaiian Islands, 13 G. E. 218 two-motor car equipments with K. 36 controllers.

The Fort Wayne Electric Works have sold to the Southern Sierras Power Company 48 distribution transformers of the outdoor type, for use in connection with a 30,000-volt transmission line.

The National Conduit & Cable Company of New York has added to their various departments a large brass foundry under special laboratory supervision, for making high class castings of all description.

The Seattle, Renton & Southern Railway Company has placed an order with the Westinghouse Electric & Manufacturing Company for six double equipments of Number 317 Motors with type HL, U.S.G. control.

On February 1st the Westinghouse Air Brake & Traction Company, will remove the office of their Southeastern manager, Mr. E. A. Craig, from the General Office, Wilmerding, Pa., to 308 Westinghouse Building, Pittsburg, Pa.

One of the great electric traction systems of the south, the Piedmont and Northern Lines, is about to enter the telephone train dispatching field, and with this end in view has placed orders with the Western Electric Company for equipment to be used on two of its lines.

The Stewart-Fuller Company have moved their office and warerooms from 143 Second street to 40 Stevenson street, San Francisco, in addition to carrying a stock of Vulcan soldering irons, curling irons and flat irons, Nokorode soldering paste, and Peirce expansion bolts, they are also agents for underground clay conduit and Peirce line material for telephone and power work.

The Westinghouse Electric and Manufacturing Company has sold to the East Shore and Suburban Railway Company one 1500-kw. motor-generator set, which is to be installed in the present substation at Richmond. This will provide additional direct current capacity for the operation of trolley cars.

The Telephone-Electric Equipment Company, Pacific Coast sales agents, announce a new non-metallic flexible conduit placed on the market by the National Metal Molding Company of Pittsburgh. The name of this new product is Flextube, a continuous circular tubing constructed from specially prepared rigid fibre wood, formed into a helix, and interwoven with warp. There are no separable parts. The result is a very closely woven inner tube, securely held in circular form, and this surface is soapstoned to give added smoothness. This will be manufactured in the 2-8 in. and 5-16 in. as well as in the 3-8 in. size.

NEW CATALOGUES.

The Steel City Electric Company of Pittsburg, Pa., is distributing a pamphlet entitled "Steel City," which sets forth steel outlet boxes of various designs.

The Steel City Electric Company of Pittsburg is distributing Bulletin E describing Fullman adjustable watertight floor outlets. A partial list of buildings equipped with Fullman outlets is enclosed.

The Brill Magazine for January has a neatly illustrated article on conditions which govern car service in Vienna, Austria, and will be found interesting to those engaged in city street car development.

The National Tube Company of Pittsburg has just published a correction sheet No. 4 for Catalog H of 1909. This sheet includes all corrections previously incorporated in correction sheets Nos. 1, 2 and 3A.

The Union Iron Works Company of San Francisco is distributing Catalog No. 5 which deals with Evans hydraulic elevators and hydraulic mining machinery. The booklet is neatly illustrated with installations made by the company and describes parts connected with their hydraulic and mining equipment offered to the trade.

The Sprague Electric Works of the General Electric Company has just issued Bulletin No. 239 on full automatic push button control systems for the operation of newspaper presses. The booklet will be found interesting and profitable reading to those in any way engaged in improving economy in the operation of the printing press.

George J. Henry, Jr., hydraulic and mechanical designing and constructing engineer, of San Francisco, has just distributed an interesting and attractive pamphlet on "Water Power." The pamphlet sets forth the economic and efficient development and use of water power for hydroelectric transmission and for mining and industrial purposes.

"Warren Beautiful" is the title of a handsomely illustrated publication of thirty-six pages put forth by the Sterling Electrical Manufacturing Company of Warren, Ohio. The paper prepared by J. Robert Crouse interestingly details the advantages of a city, the first to adopt the mazda street lighting to the exclusion of all other street lighting methods.

The Simonds Machinery Company of San Francisco is distributing hand book and Catalog No. 7 of the Kewanee Water Supply Company, Kewanee, Ill. The booklet is handsomely illustrated and ably sets forth recent development in water supply and is of interest to those engaged in improving their present apparatus for this branch of the mechanic art.

G. A. Wilbur, electrical manufacturer's agent of San Francisco, is distributing Bulletin No. 22 of the Duncan Electric Manufacturing Company. The bulletin sets forth the features of Duncan Type Model R watthour meters wherein no magnetic shields are needed, no iron is utilized in the armature, and the meter accuracy is not impaired by short circuits.

The Westinghouse Electric & Manufacturing Company has issued Descriptive Leaflet No. 2298 describing its well-known type CCE induction motor. The company has also just issued Leaflet No. 2330 covering a direct current (Type JL) vertical edgewise switchboard ammeter operating on the D'Arsonval principle with a single air-gap.

The Simonds Machinery Company of San Francisco is distributing Catalog No. 18 of the American Steam Pump Company, Battle Creek, Mich. The catalog is profusely illustrated. It details in a systematic and clear manner the various designs of pumps offered by them which covers the entire field wherein a pump is used for any purpose whatsoever.

NEW CATALOGS PUBLISHED BY THE GENERAL ELECTRIC COMPANY.

Bulletin No. 4917 illustrates and describes direct current exciter panels. Bulletin No. 4893 is devoted to a general description of two automatic time switches. Bulletin No. 4901 is devoted to alternating current switchboard panels with oil switches attached. Bulletin No. 4906 is devoted to the lighting of textile mills and in this connection considers those items briefly. The publication is enclosed in a rather striking cover. Bulletin No. 4904 illustrates and describes three-phase panels for use in small or isolated plants containing but one generator. Bulletin No. 4905 is devoted to panels designed for general use in small central stations and isolated plants. Bulletin No. 4924 describes the Thomson prepayment watthour meters for direct and alternating current, Types CP-4 and IP-4. Bulletin No. 4918 illustrates and describes panels designed for general use in central stations. Small plant direct current switchboards is the title of Bulletin No. 4919. The bulletin is devoted to a description of panels which are designed for the control of three-wire generators. Bulletin No. 4920 describes the GE-203A railway motor which is of the box frame, commutating pole type, rated at 50 h.p. on 600 volts and 40 h.p. on 500 volts. Bulletin No. 4887 is an attractive bulletin illustrating and describing the General Electric Company's turbo-generator sets in capacities of from 5 to 300 kw. Bulletin No. 4900 is devoted to apparatus used in connection with series incandescent street lighting, and supersedes in part the company's previous bulletin on this subject. Bulletin No. 4907 recently issued by the General Electric Company contains interesting data relative to the lighting of offices, banks and public buildings by G. E. Edison mazda lamps.

NEW PUBLICATIONS—BUREAU OF MINES.

Bulletin:—Bulletin 15. Investigations of explosives used in coal mines, by Clarence Hall, W. O. Snelling, and S. P. Howell, with an introduction by C. E. Munroe, and a chapter on the natural gas used at Pittsburgh, by G. A. Burrell. 1911, 197 pp., 7 pls.

Technical Papers:—Technical Paper 6. The rate of burning of fuse as influenced by temperature and pressure, by W. O. Snelling and W. C. Cope. 1911. 22 pp. Technical Paper 7. Investigations of fuse and miners' squibs, by Clarence Hall and S. P. Howell. 1911. 19 pp.

Reprints:—Bulletin 31:—Incidental problems in gas-producer tests, by R. H. Fernald, C. D. Smith, J. K. Clement, and H. A. Grine, 29 pp. Reprint of United States Geological Survey Bulletin 392. Copies will not be sent to persons who received Bulletin 392. Bulletin 32. Commercial deductions from comparisons of gasoline and alcohol tests on internal combustion engines, by R. M. Strong. 38 pp. Bulletin 33. Comparative tests of run-of-mine and briquetted coal on the torpedo boat Biddle, by W. T. Ray and Henry Kreisinger. 49 pp. Reprint of United States Geological Survey Bulletin 412. Copies will not be sent to persons who received Bulletin 412.

NEWS NOTES

SPECIAL CORRESPONDENCE.

SEATTLE, WASH.—The final hearing by the State to determine the valuation of the Pacific Telephone & Telegraph Company's property in the State of Washington, brought out the fact that this company pays to the American Telephone & Telegraph Company 41½ per cent of its earnings, or approximately $40,000. The commission is to investigate this charge as it is believed to be excessive. Edgar S. Bloom, New York, in charge of plant operation of the American Telephone & Telegraph Company; H. D. Pillsbury, general counsel; A. H. Griswald, plant engineer, and O. W. Berkett, general superintendent of the Pacific Telephone & Telegraph Company, were present at the meeting concerning the fear of the City Council that the public service commission is trying to assume jurisdiction over municipal plants. Commissioner G. A. Lee said that there is no ground for fear. The commission can not and does not want to control municipal plants but, simply wishes to act in conjunction with them for the good of all.

All companies operating on Puget Sound under the management of Stone & Webster have consolidated under the name of the Puget Sound Traction, Light & Power Company. A certificate of organization has been filed, naming Portland, Me., as the headquarters of the company, and Richard T. Laffin of Seattle, general manager. The trustees are Chas. M. Drummond, president; Wadleigh B. Drummond, secretary and treasurer, and Josiah H. Drummond.

The commissioners refused the Puget Sound Electric Company a franchise to set poles and string wires along the county road between Orillia and Auburn. About 200 property owners, offended by the rise in transportation rates of the company, protested against granting the franchise.

The foreman of the pile driving gang, on the bulkhead of the Twelfth avenue South bridge was electrocuted by a water soaked pile touching the high tension wires of the Snoqualamie Power Company. Several others were knocked down but not badly hurt.

An inspector of the local gas company discovered a pipe not connected with the meter in a lodging house, run by Mrs. Ida M. Anderson, and suspecting larceny of gas so reported to the company. The gas company immediately shut off the service connection and brought a criminal charge against Mrs. Anderson. She was acquitted of the charge and brought suit for damages to business against the company and was awarded $250 by the jury.

Interests represented by Sanderson & Porter have taken over the franchise and property of the South Bend-Raymond Electric Company. The consideration is said to be $100,000.

The Seattle Electric Company's report to the commission shows that during 1911 there were 71,480,189 fares rung up, while 4,498,107 employees and others were carried free. The average fare was 4.8 cents. The passenger revenue was $3,425,380.07, freight $87,581, and the mail contract $10,275. Ten people were killed and 3492 injured; $241,872 or 9½ per cent of the operating expenses, was paid for injuries and damages. The operating expense was 70.58 per cent of the operating revenue.

PORTLAND, ORE.—There is much dissatisfaction over the January bills of the Hood River Gas & Electric Company at Hood River, as they are about 300 per cent higher than ever before. The company is trying to get the consumers to make a flat rate contract for one year. They promise to annul the January bill and date the year's contract from January 1, 1912. About 100 consumers have gone over to the hydroelectric company.

A new telephone line to be known as the Mutual Telephone Company, is to run from Seaside to Elk Creek river, a distance of nine miles. The new line will have long distance connections with the Pacific States Telephone & Telegraph Company.

Vancouver, Wash., is being entertained by a newspaper controversy between the Portland Railway, Light & Power Company and the Washington-Oregon Corporation relative to the merits of electric arc light and gas arcs for street lighting. The contract for lighting the streets for the next ten years comes before the council this week.

The California & Oregon Power Company has recently purchased the Rogue River Electric Company, the Siskiyou Electric Power & Light Company, and twenty-three other companies operating in the neighborhood of Medford. The purchase price is said to be $10,000,000. Officers of the new company are J. M. Churchill, president, Yreka, Cal.; Alex. J. Rosborough, secretary, Oakland, Cal.; A. C. Hough, general counsel, Grants Pass, Ore. Main offices are to be in San Francisco. The aggregate horsepower is to be 250,000, of which the new power station on the Klamath River, about 20 miles from Fall Creek, is to furnish 150,000 and the one already at Prospect, about 50 miles from Medford, can furnish 50,000. Other stations are to be at Gold Ray, Fall Creek, Little Shasta, and Yreka.

LOS ANGELES, CAL.—The City Council has signed and ratified a contract selling $9,390,000 of the aqueduct, power, and harbor bonds to Speyer & Co., of New York. The conditions of the sale are at par with accrued interest at 4½ per cent and the city agrees to create no additional debt until after January 1, 1913. This stipulation does not interfere with any proposition of the city at present. The syndicate takes $2,890,000 of aqueduct bonds, but not $1,326,000 of the aqueduct now in the sinking fund, $3,000,000 of harbor, and $3,500,000 of the power bonds, making a total of $9,390,000. The sale is not optional but firm and calls for the acceptance of the issues in installments before the end of the year.

Aqueduct salvage valued at $1,000,000 is almost ready for the market. The principal items are the $800,000 cement mill at Monolith, the power stations at Cottonwood and Division creeks, and the tufa grinding mills at Fairmont and Haiwee. Whether to sell the big mill at Monolith or retain it and run it in competition with private enterprise is perplexing the council at present. Tufa cement is rapidly gaining in favor with the government engineers. The power stations will be sold to the power department of the city only, and will be run with Haiwee, San Francisquito and San Fernando to make the great aggregate of 120,000 horsepower.

SPOKANE, WASH.—The annual meeting of the Washington Power Company was held February 5, 1912 and trustees elected as follows: W. A. White, Hinsdill Parsons, Frank Lyman, F. S. Bangs, Theodore F. Hicks, H. T. White, Jonathan Bulkley, O. F. Jellikoffer, B. B. Lawrence, Guy Du Val, and Edwin G. Merrill, all of New York; Philip Cabot of Boston, H. M. Richards, J. P. M. Richards, L. M. Davenport, W. J. C. McCrea, and D. L. Huntington, all of Spokane. The following figures are taken from the report:

Total assets	$20,798,071
Capital stock	14,076,900
Outstanding bonds	5,731,000
Street paving between tracks and track improvements in four years	1,035,517
Passengers carried in 1911	23,691,820
Car miles run	3,982,362
Power capacity when Long Lake work is complete	139,000 h.p.
Gross receipts	$ 3,264,168.36
Net earnings	989,682.98
Expenses, including taxes	1,652,980.84
Taxes	157,330

The Little Falls Station of this company, designed and built by their own engineers, is said to be one of the finest in the country, both in construction and efficiency. A stor-

age battery has been installed to carry theatre and other loads in case of interruptions of service.

The company laid about 147,000 duct feet of underground conduit and drew in 109,100 feet of underground cable during the year.

Work at Long Lake is going on steadily with about 400 to 500 men employed. There is very little sickness at the camp, due to the excellent sanitary conditions. The concrete dam at this place will be 170 feet high and will store a lake of water 23 miles long and averaging seven-eighths of a mile wide. The entire work is to be done by 1913. The 139,000 horsepower is divided up as follows: Spokane power station, 12,000 h.p.; Post Falls, 15,000 h.p.; Little Falls, 27,000 h.p.; Long Lake, 66,000 h.p.; and Spokane (steam station), 19,000 h.p. In addition there is 25,000 undeveloped h.p. in Spokane. The increase in customers was 6 per cent. The mean rate of interest on the investment is about 6 per cent. For 1912 the estimate of expenditures is $1,510,205 for improvements in both electric light and power service and street railroad work.

The Pacific Telephone & Telegraph Company recently gave a dance to promote good fellowship among its Spokane employes.

INCORPORATIONS.

MOLALLA, ORE.—The Molalla Telephone Company has been incorporated with $2500 capital stock.

OLYMPIA, WASH.—The Reecer Creek Telephone Company of Kittitas County has placed on file articles of incorporation. The capital is $300 and the incorporators are S. Kreidel, W. J. Cahoon, and W. Spurling.

SAN BERNARDINO, CAL.—The Yucaipa Domestic Water Company has incorporated with a capital stock of $50,000, and will develop the Yucaipa Valley country. The incorporators are G. A. Atwood of San Bernardino; J. H. Dike and J. H. Logie of Redlands. Redlands is the principal place of business.

PENDLETON, ORE.—Articles of incorporation have been filed for the Interior Electric Power Company, which is to be financed by both Milton and Pendleton citizens, and will furnish power for commercial purposes. County Surveyor Geary Kimbrell and his father have returned from Milton, where they have been surveying the proposed power site on the Walla Walla River.

SALT LAKE CITY, UTAH.—An independent power company, aiming to enter the local field in competition with the existing company, has just been organized in Salt Lake and will begin the development of its power site in the American Fork canyon early in the spring. It is capitalized at $250,000, and is known as the Earle Power Company, of which C. W. Earle is president.

SAN FRANCISCO, CAL.—Articles of incorporation of the San Francisco & Northern Railway Company, organized to build and operate an electric railroad from Santa Rosa to San Quentin, have been filed. The incorporation papers provide for a capital stock of $2,500,000, divided into 25,000 shares at $100 each, and specify that $50,000 of this has already been subscribed by the five incorporators, each of whom took a block of 100 shares. The new road is undoubtedly an extension of the Petaluma & Santa Rosa Railroad and will be 42 miles in length. Its incorporators are: Allen J. and John O. Kittle of Ross; Archibald Borland, president of the American Rubber Company of Oakland; Frank A. Brush, a director of the Santa Rosa National Bank and the Petaluma and Santa Rosa Railroad, and William L. P. Jackson, assistant cashier of E. H. Rollins & Sons, a financial institution.

GOLD RUN, CAL.—To develop electrical energy and furnish water for irrigation projects is the plan of the United Water & Power Company, a new corporation headed by James D. Stewart of Gold Run. Reservoir sites and water rights have been secured by the company on the South Yuba, Bear and American Rivers, where it is proposed to eventually build power plants. A complete report of the projects, four in number, has just been made by W. P. Ireland, a civil engineer of Sacramento, who is also vice-president of the company. In order to carry out the plans for the development of the projects, the company has authorized a bond issue amounting to $5,000,000 and a New York firm has agreed to undertake the disposal of the entire issue. The report of the engineer shows that project No. 1 provides for the development of 5200 miner's inches of water and the generation of 11,900 electrical h.p., with the construction of a power house about 2½ miles west of Blue Canyon. Project No. 2 provides for the development of 5100 electrical h.p. and a power house two miles northeast of Dutch Flat. Project No. 3 provides for the development of 13,000 electrical h.p. and a power house 1½ miles east of Colfax. Project No. 4 provides for the development of 4200 electrical h.p. and a power house 1½ miles southwest of Auburn.

ILLUMINATION.

WATSONVILLE, CAL.—The Coast Counties Light & Power Company will begin shortly to extend its lines to Corralitos.

CARLTON, ORE.—Carlton city officials have been instructed to issue bonds not to exceed $40,000 for water and light purposes.

SPRINGS, CAL.—Work has been started by the San Diego Consolidated Gas & Electric Company on extending their gas mains to La Mesa.

EUREKA, CAL.—A municipal light, power and water plant, costing $1,000,000, was recommended by the mayor in his annual message to the City Council.

SANTA ROSA, CAL.—The application of the Great Western Power Company for a franchise to construct electric poles and lines in this city, was granted, and the franchise passed to print. The company will submit a bid for the city lighting and power on February 20.

KALESPELL, MONT.—The engineers who have been at work at Kootenai falls for the past month have completed their examinations of the power-site there and have returned to New York to prepare their report on the plan to use these falls for obtaining power for the Coeur d'Alene mines and various cities, including Spokane. The Kootenai Construction Company is the corporation organized by Joseph A. Coram of Boston to develop the power.

SAN RAFAEL, CAL.—The Western Power Company has applied to the Marin Supervisors for a blanket franchise to erect poles along the high ways of the county in competition with the present lighting company. In the last few days similar franchises have been applied for in Napa, Solano and San Mateo counties. The Supervisors oppose giving a franchise of that kind, being of the opinion that the routes should be outlined.

FRESNO, CAL.—At a recent executive meeting of the Board of City Trustees an agreement was reached to pass an ordinance lowering the price of gas to $1 a thousand. The present rate is $1.50 per 1000 cubic feet. The ordinance will be passed in all probability at the next meeting, with the understanding that it is not to go into effect until the fall. This is being done to allow the gas company to make the improvements it considers necessary before the new rate goes into effect.

SAN FRANCISCO, CAL.—An announcement is made that Mortimer Fleishhacker has been selected as president of the

Great Western Power Company, in succession to Edwin Hawley, the railroad magnate of New York, who died last week. This carries with it the presidencies of the two subsidiary corporations, the California Generating Company of Oakland and the City Electric Light & Power Company of San Francisco. A. W. Bullard of Boston comes here as the active vice-president under Fleishhacker.

TRANSMISSION.

TACOMA, WASH.—The plant of the St. Paul & Tacoma Lumber Company will be electrified, according to Everett G. Griggs, president of the company.

HEMET, CAL.—Sealed bids will be received up to March 27th for the purchase of a franchise granting the right to construct and maintain for a period of fifty years an electric pole, tower and wire system consisting of all the necessary apparatus for transmitting electricity along the public streets, alleys and roads of the town.

LOS ANGELES, CAL.—The Southern California Edison Company reports an income of $1,728,603, of which $728,376 was from power, the remainder being from light. It sold 16,308,950 kw. hours of light current, and 50,855,954 of power current. It reports a gross income of $379,000. It gives its plant valuation at $9,122,480 for tangible property, and adds $2,280,620 as going or unit value as a concern with assembled property and connected business. In this valuation the distributing system is valued at $2,705,503, and the hydraulic system at $1,980,412. In addition to its city sales the company reports sales outside the city aggregating 82,601,386 kw. hours. For its San Pedro gas system it reports a valuation of $82,721, a manufacture of 13,817,500 cubic feet of gas and an income of $18,331, with expenditures of $15,861.

TRANSPORTATION.

SACRAMENTO, CAL.—The application of the Oakland, Antioch & Eastern Railway Company for a franchise to cross the M street bridge, will soon be presented to the Board of Supervisors.

SAN FRANCISCO, CAL.—H. W. Clapp, who has had charge of the electrical construction of the transbay lines of the Southern Pacific, has been appointed assistant electrical engineer of the company under A. H. Babcock.

HAYWARDS, CAL.—Work will soon commence on another electric line for Castro valley. An appropriation has been made by the Pacific Gas & Electric Company to run a line on the western side of the valley along the Lake Chabot road.

COLUSA, CAL.—The West Side Electric Railroad have applied for a franchise in Colusa County, granting permission to construct a road across the streets in Hershey, Arbuckle, Harrington, College City, Berlin, Williams, Colusa Junction, Maxwell, Delevan and Princeton.

SALT LAKE CITY, UTAH.—Work on an interurban electric railway that will give Salt Lake City connections with Nephi and intermediate points on the south and with Brigham City and eventually with Logan on the north and east, will be started as soon as a franchise can be obtained.

SAN FRANCISCO, CAL.—The Board of Public Works has formally turned over to the Bureau of Engineering the control and direction of the Geary street railway construction, and directed Engineer W. N. Larned, who has been in charge since the removal of former Superintendent of Construction Patrick Broderick, to turn over all plans, papers, tools and paraphernalia appertaining to the work, to City Engineer Manson, together with a proper inventory of all this property.

RICHMOND, CAL.—The East Shore & Suburban Railway Company, preliminary to double-tracking and enlarging the Richmond service, is preparing to increase its power equipment and enlarge its car barn here. It has on the way from the East a new 1500 kw. generator that will cost $40,000. The United Properties Company have part of its system double-tracked to Twenty-third street and Macdonald avenue in time for the picnic season, so as to accommodate the traffic to East Shore and Grand Canyon parks.

FRESNO, CAL.—Paul Shoup, general manager of the electric roads of the Southern Pacific has announced that the Fresno Traction Company is ready to begin construction of its line to the cemetery and confirmed the report that the road would probably go out Olive avenue. Money for the construction of the road has been authorized and the company is ready to start work as soon as the rights of way have been secured. The line will be double-tracked, with the poles in the center and arms extended for the trolley wires. The extension, from Forthcamp and Olive avenues, will be about a mile and a quarter in length. Work will start before the first of March, if rights of way are secured by that time.

TELEPHONE AND TELEGRAPH.

SAN JOSE, CAL.—The petition of E. D. Franks and others for a franchise for a farmers' telephone line from Santa Cruz County to the town limits of Los Gatos was granted.

LOS ANGELES, CAL.—After operating a wireless telegraph system between Los Angeles and Kansas City, the officials of the Federal Telegraph Company are now preparing to extend operations to Chicago.

SAN LEANDRO, CAL.—After much opposition, the Board of Trustees of this town has decided that all electric light and power wires supported by poles within the town limits must come down and be installed underground within 90 days. To this effect the city clerk was instructed to communicate with the Pacific Telephone & Telegraph Company, Postal Telegraph Company and the Pacific Gas & Electric Company advising them of the action of the board and requesting that the work be completed within 90 days.

PASADENA, CAL.—According to the officials of Pasadena and Los Angeles Home Telephone Company, there is apparently no relief in sight for those who have made application for telephones in this city. It is alleged that the unwillingness to install more telephones in the city is caused by the inability to secure a satisfactory franchise, and that the company will not put in the necessary thirty or forty thousand dollars' worth of poles and equipment without being safeguarded by a franchise. It is stated that over 300 applications for phones are being held up. The Inter-city Commission is wrestling with the problem of obtaining a single centralized telephone system for Pasadena, South Pasadena and Alhambra.

SAN FRANCISCO, CAL.—Before the public utilities committee of the Supervisors at their recent meeting, a committee representing the Los Angeles stockholders of the Home Telephone Company, appeared in behalf of the proposal to transfer the property and holdings of the company in San Francisco to the Pacific Telephone & Telegraph Company. James Slosson was the first spokesman for the Los Angeles capitalists, and told the committee that for two years the Home Telephone Company has not received any returns whatever from its eight to nine million dollars' investment. The people of San Francisco did not seem to want two systems, and if a dual system was not desired the Los Angeles stockholders should not be required any longer to put up money to cover losses. He therefore requested that early attention be given the proposed ordinance permitting the Home company to surrender its charter and dispose of its physical properties to the Pacific Telephone & Telegraph Company. Mayor Rolph replied to the Los Angeles representatives that the consummation of the plan of transfer would not have the clear sailing they appeared to anticipate. Chairman Vogelsang told the visiting committee that after all the points raised by the mayor had been given due consideration the utilities committee would make its recommendation.

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Buckeye Electric Company, The.....
Century Electric Company.....15
Colonial Electric Company.....
Colonial Electrical Agency Company.....
Crocker-Wheeler Company 8
Cutler-Hammer Mfg. Co. .....
D. & W. Fuse Company.....
Dearborn Drug & Chemical Works.....13
Duncan Electric Manufacturing Company .....
Economy Electric Company.....
Electric Storage Battery Company.....
Electrical Engineers' Equipment Company..... 2
Farnsworth Electrical Works .....
Farrar & Company, J. C.....
Fort Wayne Electric Works.....
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General Electric Company..... 14
Gould Storage Battery Company..... 8
Habirshaw Wire Company..... 2
Hammel Oil Burner Company.....
Hemingray Glass Company.....15
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Holophane Company .....
Home Telephone Company.....
Hughes & Company, E. C.....13
Hunt, Mirk & Company.....
Indiana Rubber & Insulated Wire Co.....16
Johns-Manville Co., H. W..... 5
Kellogg Switchboard & Supply Co.....
Kelman Electric & Manufacturing Co.....
Klein & Sons, Mathias..... 2
Leahy Manufacturing Co. .....
Locke Insulator Manufacturing Co..... 4
McGlauflin Manufacturing Co. .....
Moore & Co., Engineers, Chas. C..... 3
Multiple Arch Hydraulic Construction Company, Ltd.....15
National Metal Molding Company.....16
New York Insulated Wire Company.....
Ohio Brass Company.....
Okonite Company 16
Pacific Gas & Electric Company.....13
Pelton Water Wheel Company.....13
Pierson, Roeding & Company..... 4
Pittsburg Piping & Equipment Company.....16
Portland Wood Pipe Company..... 2
Safety Insulated Wire and Cable Co. .....
Schaw-Batcher Company Pipe Works, The .....
Southern Pacific Company.....16
Sprague Electric Works 5
Standard Electrical Manufacturing Company.....
Standard Underground Cable Company.....16
Technical Book Shop 15
Tracy Engineering Company.....
Thomas & Company, R.....
Western Electric Company..... 5
Westinghouse Machine Company.....
Westinghouse Electric & Manufacturing Co..... 6
Weston Electrical Instrument Company..... 3
Wilbur, G. A..... 5

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